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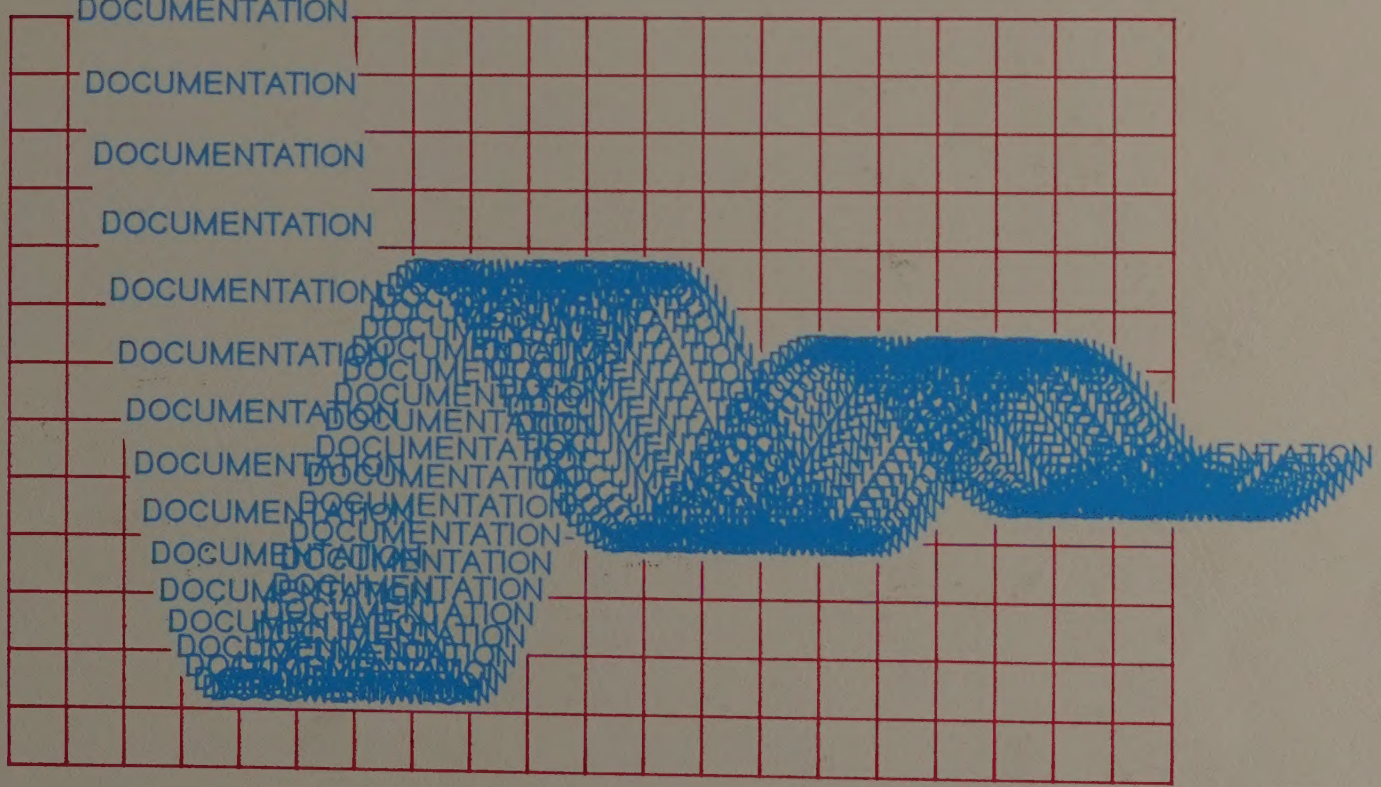
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ROHDE&SCHWARZ
Test and Measurement
Division

Operating Manual

I/Q-Modulation Generator

AMIQ

1110.2003.02/03/04

valid as of firmware version 3.04

Printed in the Federal
Republic of Germany

Supplement to AMIQ operating manual

AMIQ software version 3.04 has been superseded by 3.05.
The changes are described below.

As it was ...	And now ...
	... there is a further software option **"Digital Standard W-CDMA TTD-Mode (3GPP)" (AMIQK13)** for interpreting a waveform file created by **WinIQSIM**™ version 3.60 or higher. WinIQSIM can generate signals according to 3GPP W-CDMA TDD (3GPP TDD for short). 3GPP TDD (3rd Generation Partnership Project Time Division Duplex) designates a mobile radio transmission method developed by 3GPP (http://www.3GPP.org). 3GPP TDD is a mobile radio standard in which available bandwidth is divided among subscribers according to frequency (FDMA), time (TDMA) and code (CDMA). The same frequency is used for both directions of transmission (TDD). Each resource (i.e. a combination of frequency, code and time slot) can be used simultaneously by several base or mobile stations provided the scrambling codes differ.
... the IDLE tag contained the value 16000 after the *RST command, which produced a negative level at the I/Q outputs. This tag defines the idle signal, i.e. the two ASCII-coded 16-bit values output while the waveform is already in the output buffer but not yet being output because AMIQ is waiting for a trigger event	... the IDLE tag contains the value 32768 after the *RST command so that 0 V is present at the outputs.
... the error message "for clock > 2 MHz, length must be a multiple of 4" was output at a clock frequency > 2 MHz when the sample rate was not a multiple of 4, and the 2 MHz overlap range between the SLOW and the FAST mode was not taken into account.	... the error messages is correctly output even in the overlap range between the SLOW and the FAST mode.
... only the IEC/IEEE-bus command *GTL was available for switching from Remote to Local.	... for reasons of compatibility with the R&S instruments UPD and UPL, the SYST:COMM:GTL is available in addition for switching from Remote to Local.
... the BERT:STOP command in the response to the BERT:RESULT? query did not set the Ready bit (4th value in response string).	... error eliminated.

As it was ...	And now ...
... the tuning voltage for the internal 10 MHz reference oscillator was temporarily set to maximum when the AMIQ selftest was called ("`*TST?`" or "`DIAGnostic:SELFtest:REFFrequency?`") with the result that the frequency of the I/Q signals was slightly detuned unless the instrument was switched off and on again after the selftest. After switching the AMIQ off and on, the factory-set tuning voltage was valid again and the unit functioned correctly.	... error eliminated. The tuning voltage of the internal 10 MHz reference oscillator remains unchanged even after the selftest.
... AMIQ could not be addressed for 5 s after the SYST:BEEP command.	... error eliminated.

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Safety Instructions
Certificate of Quality
EU Certificate of Conformity
List of R&S Representatives

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I/Q Modulation Generator AMIQ
I/Q Simulation Software WinIQSIM

New approaches in the generation of complex I/Q signals

AMIQ

- 14-bit resolution
- 4000000 samples memory depth
- 100 MHz sample rate
- Integrated hard disk and floppy disk drive
- Optional BER measurement (AMIQ-B1)
- Optional differential outputs (AMIQ-B2

WinIQSIM

- Calculation of digitally modulated I/Q and IF signals
- Single-carrier, multicarrier and W-CDMA signals
- Optional IS-95 CDMA (AMIQ-K11)
- Versatile data editor
- Superposition/simulation of impairments
- Graphic display

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Modulation generator...

High sampling rate

- 100 MHz clock rate per channel
- Up to 4000000 samples memory capacity
- Generation of broadband digital communication signals (eg W-CDMA)

Stored waveforms for recall

- Built-in hard disk for storage of calculated signals
- Downloading of calculated waveforms and signals also from integrated floppy disk drive

Precise signals

- Antialiasing filters featuring excellent frequency response and constant group delay
- Auto-alignment and additional user correction of amplitude and offset
- Fine adjustment of I/Q skew
- Wide dynamic range by use of 14-bit D/A converter, ideal for multicarrier applications

AMIQ/WinIQSIM – an ideal pair

The number of systems based on complex digital modulation methods has dramatically increased in every field of communications. I/Q modulation is therefore gaining importance for the development of such modulation methods. Modulation Generator AMIQ and Simulation Software WinIQSIM open up new dimensions for the generation of I/Q signals.

AMIQ is a dual-channel modulation generator that has specially been designed for use as an I/Q source. It is programmed and set with Software WinIQSIM. Alternatively, AMIQ can be operated from Vector Signal Generator SMIQ.

Each channel can store 4000000 samples. Sequences of sufficient length can thus be generated even at high symbol rates. With clock frequencies of up to 100 Msample/s and a high amplitude resolution of 14 bits, AMIQ is the ideal source for any signal in the world of digital modulation.

An automatic amplitude/offset alignment as well as fine adjustment of the skew provide excellent symmetry of the two channels which previously was extremely difficult to attain with dual-channel ARB generators. The error vector can thus be minimized.

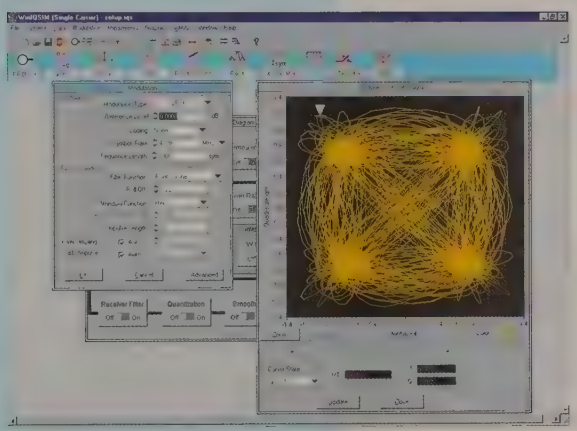
The filters have also been optimized regarding group delay, frequency response and identical configuration in the two channels for use as an I/Q modulation source.

A typical application of AMIQ and WinIQSIM is not only to drive the I/Q inputs of a vector signal generator. The combination is also ideal for direct applications in the baseband, eg for testing I/Q modulators/demodulators.

... the ultimate in I/Q signals

I/Q simulation software...

- Single-carrier signals
- Multicarrier signals (up to 512 modulated or unmodulated carriers)
- Multicarrier mixed signals (up to 32 differently modulated carriers)
- User-defined W-CDMA and CDMA signal scenarios (IS-95A optional)



- Addition of impairments
- Data editor for creating any TDMA frame configuration
- Predefined files for TDMA mobile radio standards (GSM, DECT, NADC (IS54C/IS136), PDC)
- IF signal calculation
- Graphic display of calculated signals (constellation diagram, vector diagram, i(t)/q(t), magnitude and phase, eye pattern, etc)
- Remote control of AMIQ

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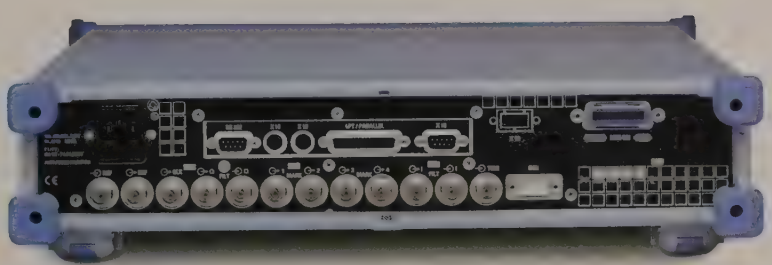
Modulation methods like GMSK or π/4DQPSK are used in mobile communication systems such as GSM (Global System for Mobile Communications) or NADC (North American Digital Cellular). These complex modulation modes are usually generated with the aid of an I/Q or vector modulator. The calculation and generation of the required baseband signals is of course quite complex.

WinIQSIM is a Windows software allowing calculation of I and Q baseband signals. Its capabilities range from single-carrier modulation, generation of multicarrier, CDMA and W-CDMA signals through to TDMA frame configuration with the help of a convenient data editor. All modulation parameters and impairments can be simulated for single-carrier and multicarrier as well as for CDMA signals. To put it in a nutshell, WinIQSIM is an indispensable tool for anyone engaged in modern digital modulation.

... versatile to the last detail



A modulation generator...

Outstanding quality (1, 2)

In addition to the great memory depth of 4000000 samples, **AMIQ** is outstanding especially for its wide dynamic range and excellent spectral purity. The built-in filters are designed for flat frequency response and nearly constant group delay.

1

Intermodulation characteristic of AMIQ at 12.8 MHz clock rate.

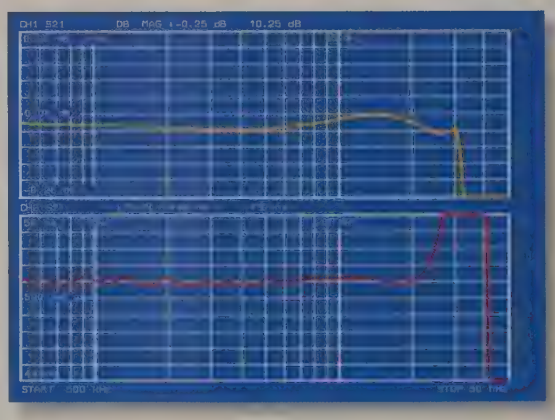
Two identical channels

For an I/Q source it is especially important for the two channels to be identical since any difference would inevitably cause an additional modulation error.

Automatic internal alignment of offset and amplitude of I and Q channel guarantees high performance. Small amplitude or offset errors of the connected device under test can be user-corrected for overall system alignment. User correction is independent of the internal automatic alignment.

Skews between the I and Q channels, which may be caused, for instance, by slight differences in the connecting cables between AMIQ and the vector signal generator, can be compensated by AMIQ with a resolution of approx. 10 ps.

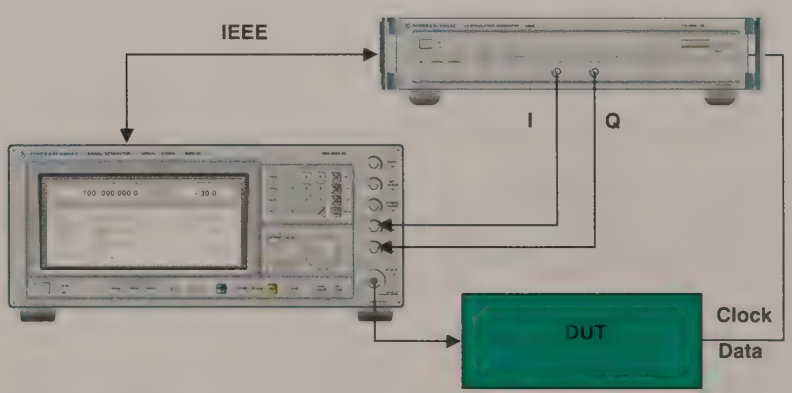
All these features are the basis for an outstanding modulation accuracy.



2

Group delay and frequency response of 25 MHz output filter

3



Example of bit error rate test

... satisfying all requirements

Synchronization capabilities

The output of signals can be triggered externally. Four user-programmable marker outputs can be synchronized to the desired sample and allow generation of sync pulses at the beginning of a timeslot. Driving the power ramping input of an RF signal generator is also conceivable.

BER measurement (3)

Measuring the bit error rate has become a frequently used method for the verification of digital communication systems (eg measuring the sensitivity or selectivity of receivers, subsystems and components). The retrofittable option (AMIQ-B1) allows AMIQ to be used for these BER (**b**it-**e**rror-**r**ate) measurements. The device under test (DUT) has to deliver the data to be tested and the associated clock. If the DUT does not have its own clock, it can be generated by AMIQ and output via one of the four user-programmable marker channels. The built-in BER tester compares these data with the nominal data and calculates the error rate. The result of the BER measurement is available via the remote-control interface. Various standard PRBS sequences (PN9, PN15, etc) are used as nominal data.

Use in development

AMIQ considerably enhances the variety of applications of a vector signal generator. It takes over where the internal modulation capabilities of a vector signal generator reach their limits. For instance, signals can be generated with a bit rate higher than the bit rate that can be handled by the internal modulation coder of an RF generator. The variation capability of any modulation parameter including the superposition of impairments and the generation of IF signals with the aid of WinIQSIM is far beyond the facilities of a conventional signal generator. The special conversion program AMIQ-K2[1)] allows the use of existing signal data that were generated with the aid of mathematical programs.

1) can be downloaded from www.rsd.de

Use in production

For use in production environments, measuring instruments have to satisfy versatile requirements. One of the main points of interest is the space they require. Since AMIQ has no built-in display, it is low in height which makes it especially interesting for rack-mounting in ATE systems. AMIQ and WinIQSIM were designed for high-speed remote control via the IEC/IEEE bus. Predefined signals can be stored on the internal hard disk and downloaded fast into the output memory.

Another benefit of AMIQ is its three-year calibration interval: it reduces costs and increases availability.

... for operation see page 11

Differential outputs

The retrofittable option AMIQ-B2 adds two outputs to the generator where the inverted $\overline{I}$ and $\overline{Q}$ signals are available.

To meet all requirements, AMIQ-B2 allows a DC (bias) voltage to be superimposed on the balanced modulation signal (eg for setting the operating point). This bias voltage can be set separately for the I and Q channels with high resolution.

With option AMIQ-B2 unbalanced signals can be converted to balanced signals without an external circuit being required.

Signal output at the inverted outputs can be switched off so that AMIQ provides only unbalanced I/Q signals.

WinIQSIM...

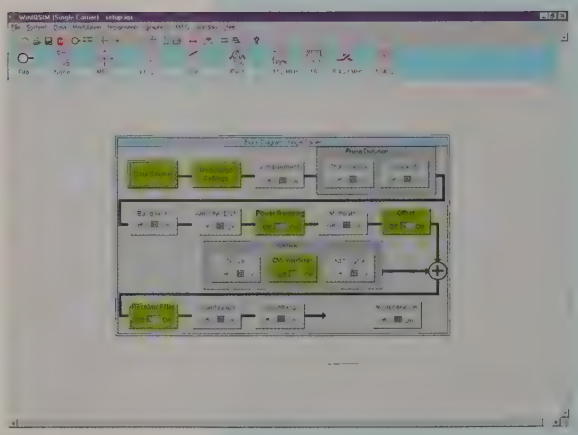
It has never been so easy

WinIQSIM was especially developed for AMIQ and is a logical continuation of the IQSIM software introduced some years ago. Compared to IQSIM, WinIQSIM has an enhanced scope of functions. Its additional features include the ability to create any TDMA frame configuration with the aid of a convenient data editor and to generate multicarrier signals as well as complex W-CDMA signals. WinIQSIM provides all the functions implemented in IQSIM. It is for instance still possible to add impairments to a signal. Thanks to the intuitive user interface special functions can quickly be found and activated. Due to its large variety of functions, WinIQSIM can be considered to be unique on the market.

Install it and go, ahead (4)

In developing WinIQSIM great importance was attached to user-friendly operation. The main parameters of a signal for instance are indicated in a status line. The context-sensitive online help enables handling of even complex functions without consulting the manual.

The program always starts with the settings of the previous session thus ensuring easy continuation of work.



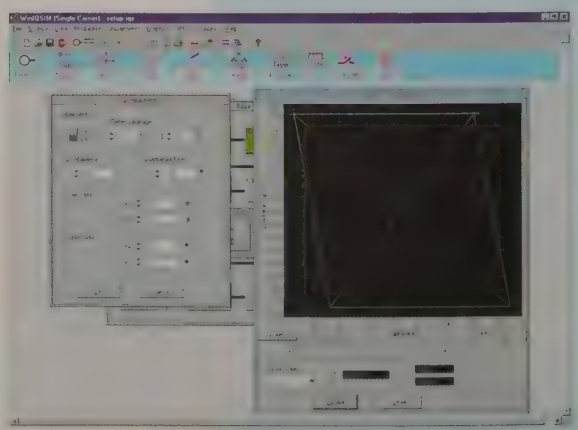
4

Clearly structured menus allow the user to get quickly familiar with the program

Single carrier (5, 6)

Modulation parameters such as type of modulation, coding, symbol rate, filter and window functions as well as oversampling can be set for a single-carrier signal.

Impairments which may be caused by a real I/Q modulator are also taken into consideration. It is for instance easy to simulate I/Q imbalance, carrier leakage or quadrature error. The simulation of VCO noise or phase and

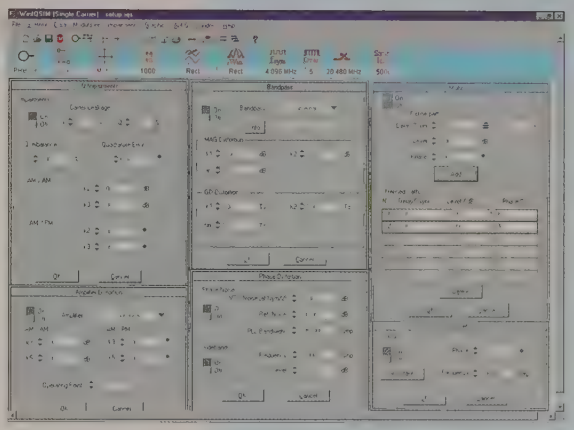


5

Simulation of I/Q impairments here for QPSK

... the ultimate in signal generation

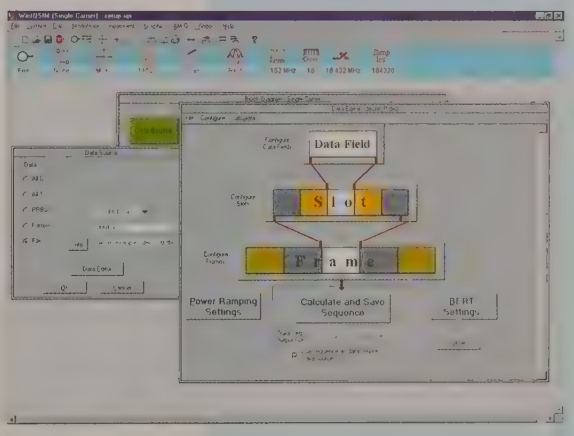
frequency offsets of an oscillator is one of the very special features of WinIQSIM. These and many other settings enable the user to take account of real impairments in the early development phase of components and modules. But also for applications in production environments signals can be composed. Such signals allow several parameters to be tested at a time and thus testing time to be reduced dramatically.



6 Setting of impairments and distortion in single-carrier mode

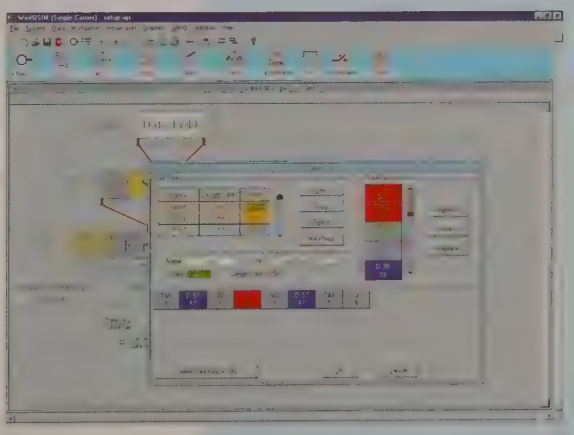
Data editor (7, 8)

Another special feature for the single-carrier mode is the data editor for convenient generation of TDMA frame structures. WinIQSIM already provides preconfigured files for the main TDMA standards such as GSM, DECT, PDC and NADC. A choice of different burst types with the associated data structure is available for the individual systems. Frame and timeslot configuration conform to the relevant standard. Basic configurations can easily be modified, stored and used again in subsequent tests.



7 Main menu of data editor...

Users specially concerned with the definition or development of new TDMA standards are offered an almost infinite number of possibilities by the data editor. The structure of a TDMA signal with its basic elements (data fields of a burst) can be completely defined and successively configured into bursts and frames. In this way it is possible to design an individual standard. In addition to the graphical representation of the data structures, power ramping can also be defined at data level.

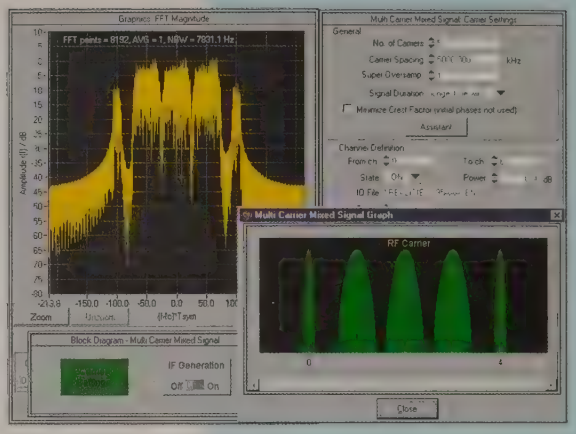


8 ... Definition of slots

WinIQSIM (continued)

Multicarrier signals (9)

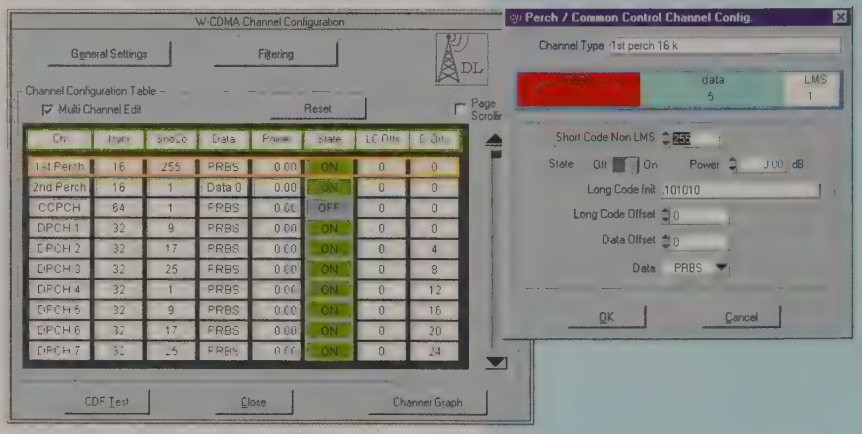
In addition to single-carrier signals, multicarrier signals with all their characteristic parameters such as number of carriers (up to 512), carrier spacing, modulation (same for all carriers) and carrier power can also be simulated. In this way a composite signal consisting of modulated and unmodulated carriers or signals with several impairments can be generated. What makes this application so attractive is that only one generator is needed to produce these signals, which means an enormous cost benefit.


Graphics: FFT Magnitude
FFT points = 8192, AVG = 1, NBW = 7821.1 Hz
Multi Carrier Mixed Signal: Carrier Settings
Multi Carrier Mixed Signal Graph
RF Carrier
Block Diagram - Multi Carrier Mixed Signal
IF Generation
Close

9

Generation of multicarrier signal with 3 W-CDMA and 2 IS-95 CDMA carrier signals

Another operating mode (multicarrier mixed signal mode) allows up to 32 differently modulated carriers with any signal from various systems (single-carrier, multicarrier, W-CDMA, IS-95) to be combined and the power varied. Thus signal scenarios such as several W-CDMA and IS-95 carriers can be simultaneously simulated and generated by AMIQ.



10

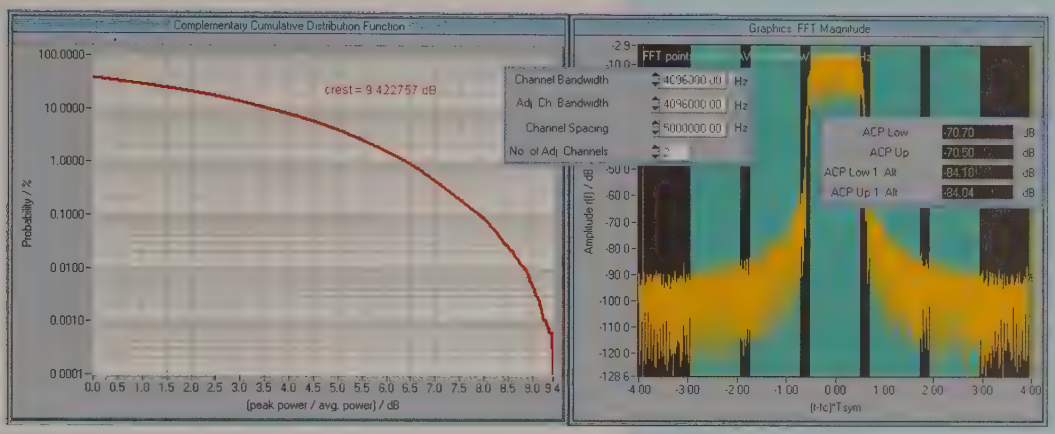
Definition of code channel scenarios for W-CDMA

CDMA? W-CDMA? – WinIQSIM! (10, 11)

In addition to the calculation of TDMA and multicarrier signals, WinIQSIM also allows W-CDMA signals to be simulated according to Japanese specifications and (with option AMIQ-K11) even CDMA signals to the American IS-95(A) standard.

W-CDMA supports all physical channels (perch 1, perch 2, downlink common control, uplink common control (64 kbit/s) and dedicated channel for

Calculation of CDF and ACPR for W-CDMA



uplink and downlink) with selectable symbol rates.

Depending on the selected symbol and chip rates, up to 512 code channels with a maximum chip rate of 16.384 Mcps can be generated. This can be useful for testing base stations under realistic and worst-case conditions.

For IS-95 CDMA, up to eight complete base stations with 64 code channels each (pilot, paging, sync, traffic) can be simulated in the forward link and up to 16 mobile stations (access and traffic) in the reverse link.

With W-CDMA and IS-95 CDMA standards, the orthogonal codes, data sources (PRBS, pattern or user-programmable sequences) and the power of the individual code channels can be varied, permitting an even greater variety of signals to be generated.

For the statistic evaluation of CDMA signal characteristics, WinIQSIM calculates and graphically displays the complementary cumulative distribution function (CDF). The resulting adjacent-channel power can be calculated in addition.

WinIQSIM's open software concept allows for a continuous adaptation to the rapid development in the field of mobile radio standards of the 3rd generation. The user is thus always up to the latest technical standard.

IF signal generation

In many communication systems the baseband signal at the transmitter end is transformed into an intermediate frequency IF before it is converted into the RF. Conversely, the received signal is converted into the IF before it is demodulated. Testing the modulators and demodulators used in such communication systems therefore requires an IF signal. With WinIQSIM the dual-channel I/Q signal is recalculated into a single-channel IF signal (up to 25 MHz). The effect of IF filters can be simulated by means of a configurable bandpass filter in the signal path.

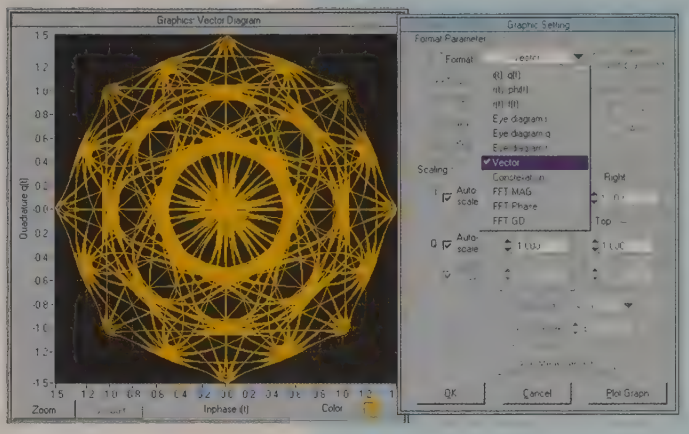
BER measurement (12)

The BER measurement option (AMIQ-B1) can be controlled by WinIQSIM or Vector Signal Generator SMIQ.

Two different modes are provided for single or continuous measurements. In the CONTINUOUS mode, the BER is continuously calculated from the total bit rate and the error bits and displayed next to the error bits.

WinIQSIM automatically indicates whether a clock or data signal is applied to the BER tester and whether the latter synchronizes to the sent PRBS sequences. If synchronization is lost at the beginning or during the measurement, AMIQ automatically triggers a restart (RESTART) of the BER measurement. The signal section to be considered in the measurement can be marked by means of an ENABLE signal. All other transmitted data will then be ignored.

13



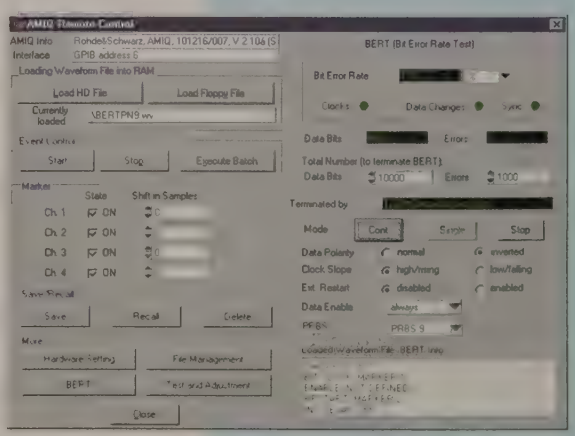
Graphics display of calculated signals

When a settable number of data bits or bit errors is attained, the BER measurement is terminated and the result displayed.

Graphic display (13)

The calculated signal can be graphically displayed and can thus already be checked before it is transferred to AMIQ. There is a choice between different display modes such as i(t) and q(t), vector diagram or signal spectrum. A zoom function and several cursors for reading the exact values are provided in the graphics panel. Moreover, a report giving the main modulation parameters and the selected graphic display mode can be output on a printer at the end of the calculations.

12



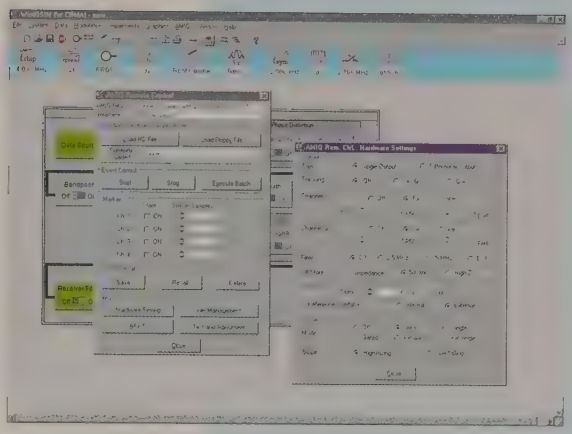
User interface for BER measurement

Operation

AMIQ, WinIQSIM and SMIQ - a perfect match

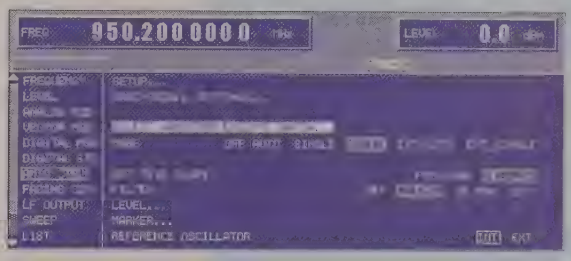
AMIQ is a black box without any control and display elements. There are several choices in the operation of AMIQ:

1. Operation via WinIQSIM (14)
With WinIQSIM, calculated signals can be downloaded to the AMIQ hard disk or directly into the RAM of AMIQ via IEC/IEEE bus or RS-232 interface. In addition, all AMIQ functions can be set in a menu under WinIQSIM.



14 User interface for controlling AMIQ via WinIQSIM

2. Operation from SMIQ (15)
A PC with WinIQSIM is only required if new waveforms are to be calculated since signals once calculated can be stored on the hard disk of AMIQ. In conjunction with Vector Signal Generator SMIQ from R&S it is possible to select waveforms stored on hard disk or floppy and change the AMIQ parameters in a special menu. In this mode, AMIQ acts as if it were an option of SMIQ.



15 Menu for controlling AMIQ with SMIQ

Flexible generation of digitally modulated signals with AMIQ and SMIQ

3. Operation in ATE systems
Like with any other remote-controlled instrument, all functions of AMIQ, eg downloading of predefined waveforms from the integrated hard disk, can be controlled via the remote-control interface. In this operating mode, neither WinIQSIM nor SMIQ is required.

Applications

Verification/type-approval testing of digital mobile phones and base stations

For the verification and type approval of mobile phones and base stations, signal generators are used for testing subsystems such as receivers, modulators and amplifiers. Due to its versatility and signal quality, AMIQ is the ideal baseband source to handle these tasks. Preprogrammed standard settings in WinIQSIM provide frame structures for all main mobile radio standards.

Use in ATE (automatic test equipment) systems

In test systems, space is usually limited. Due to its low height, AMIQ is an ideal choice as a baseband or IF signal source. For this application, AMIQ certainly benefits from its black box design with an IEC/IEEE bus optimized for high transfer rate, integrated hard disk and floppy.

Development of new communication systems

The data generator provided under WinIQSIM does not only offer predefined standard files for all common TDMA (time division multiplex access) systems but also enables the user to customize systems. There are practically no limits set to the user's creativity.

Tolerance tests

In addition to ideal signals, the combination WinIQSIM/AMIQ also allows a large number of signals with defined impairments to be generated. Variation of bit rates and filtering are used to determine tolerance limits and to detect potential critical spots in new systems. AMIQ in conjunction with WinIQSIM allows new modulation methods to be investigated under real operating conditions.

Third-generation communication systems

Signals as used by novel and future communication systems, eg CDMA or W-CDMA, as well as by wireless local loop or wireless LAN systems can be generated with little effort using AMIQ and WinIQSIM.

Adjustment of I/Q modulators

More and more ICs and modules are equipped with differential I/Q inputs. In the case of DC coupling between AMIQ and for instance a modulator chip, the I/Q signal can be superimposed by a DC (bias) voltage for setting the operating point (with option AMIQ-B2 only). This DC voltage can be set separately for the I and Q channel. A small offset voltage (user correction) can be superimposed in addition to this bias voltage to minimize the RF carrier leakage in the modulator and thus to obtain optimum data for the I/Q signal at the RF.

Specifications

AMIQ

Output memory

Trace length (data and markers)	
Clock rate mode 1 (10Hz to 4MHz)	24 to 4000000 samples in steps of one
Clock rate mode 2 (2 to 100 MHz)	24 to 4000000 samples in steps of four
Amplitude resolution of data words	14 bits
Marker channels	to be used as marker or trigger outputs
Number	4

Clock generation

Clock rate	10 Hz to 100 MHz
Setting range	10 Hz to 105 MHz [1]
Resolution	$1 \cdot 10^{-7}$

[1] Specs at clock >100 MHz not guaranteed, max. ambient temperature 35 °C

Reference frequency

Internal reference output	
Frequency	10 MHz
Aging (after 30 days of operation)	$1 \cdot 10^{-5}$/year
Temperature effect (0°C to 45°C)	$<2 \cdot 10^{-6}$/°C
Level, rms	0.5 V (into 50 Ω)
Frequency adjustment	electronic
External reference input	
Frequency	10 MHz
Level, rms	0.1 V to 2 V
Input impedance	50 Ω

Signal output

Outputs	I and Q, [1]
Output impedance	50 Ω
Output voltage (V_p into 50 Ω)	
Mode fix	0.5 V, same for both channels
Amplitude fine variation	±10 %, separately for each channel
Resolution	0.01 %
Level difference between the two channels	<0.2 % (at 1 kHz, after auto-alignment)
Residual DC offset	<0.5 mV, typ. 0.1 mV (after auto-alignment)
DC fine variation	typ. ±30 mV
Resolution	30 µV
SFDR (sinewave 1 MHz, clock rate 10 MHz)	>70 dB, typ. 80 dB
Variable mode	0 mV to 1 V, separately adjustable for each channel
Resolution	3 digits
Residual DC offset	<5 mV, typ. 1 mV (after auto alignment)
DC fine variation	typ. ±70 mV
Resolution	70 µV
SFDR (sinewave 1 MHz, clock rate 10 MHz)	>50 dB (level >0.1 V), typ. 70 dB (level >0.5 V),
Skew between I and Q channel (filter off, clock rate 10 MHz, fix mode)	
Fine variation	typ. ±1 ns
Resolution	<10 ps
Effective bits (sinewave 5 MHz, clock frequency 50 MHz, fix mode)	typ. 11
Rise time	typ. 5 ns

[1] $\overline{I}$ and $\overline{Q}$ in addition when option AMIQ-B2 is used

Error vector

IS-95 (QPSK)	typ. 0.35% EVM (rms)
GSM (GMSK)	typ. 0.2° phase error (rms)
DECT (2FSK)	typ. 0.9% FSK error
NADC, PHS (π/4DQPSK)	typ. 0.3% EVM (rms)

Filter

Operating modes		off (no filter), internal or external filter
Internal filter		
25 MHz, elliptic, 7th order + delay equalizer		
Freq. response	Amplitude	typ. 0.15 dB up to 25 MHz
	Group delay	typ. 500 ps up to 20 MHz
I/Q imbalance	Amplitude	typ. 0.05 dB up to 25 MHz
	Group delay	typ. 200 ps up to 20 MHz
Stopband attenuation		70 dB from 75 MHz
2.5 MHz, elliptic, 7th order + delay equalizer		
Freq. response	Amplitude	typ. 0.15 dB up to 2.5 MHz
	Group delay	typ. 5 ns up to 2 MHz
I/Q imbalance	Amplitude	typ. 0.05 dB up to 2.5 MHz
	Group delay	typ. 1 dB up to 2 MHz
Stopband attenuation		70 dB from 7.5 MHz
External filters		one filter can be connected for each channel, BNC connectors on rear panel
Impedance		50 Ω

Trigger

CONT mode	repetitive output of loaded trace after occurrence of trigger
SINGLE mode	single output of loaded trace after occurrence of trigger
GATED mode	start of (repetitive) waveform output after occurrence of trigger until end of trigger event
Trigger signal	via remote control or trigger input
Trigger input	BNC connector, selectable polarity
Input level	TTL
Max. permissible input voltage	–0.5 V to 6 V
Pulse width (clock rate mode 1)	min. 200 ns + 1 sample
Pulse width (clock rate mode 2)	min. 11 samples
Delay between trigger input and output of 1st data word	mode 1: 220 ns + (1 sample+20 ns) jitter mode 2: 21 samples + 1 sample jitter

Marker outputs

Number	4, BNC connectors
Level	TTL, can be terminated into 50 , (high >2 V)

BER tester (option AMIQ-B1)

Data supplied by the DUT can be compared with a nominal random bit sequence; the results are transferred to the host computer (via the currently used remote control); the BER measurement can be controlled from WinIQSIM and SMIQ.

Quasi-random bit sequences	2^9-1, $2^{11}-1$, $2^{15}-1$, $2^{16}-1$, $2^{20}-1$, $2^{21}-1$, $2^{23}-1$
Clock source	supplied by DUT, each valid bit requires a clock
Clock rate	max. 20 MHz
Sync period	24 clocks
Interface	9-pin sub-D connector, DSUB-BNC cable supplied in addition
Data	TTL
Data enable	TTL
Clock	TTL
Restart	TTL
Setup time	10 ns
Hold time	2 ns
Polarity	normal and inverted (data, clock, data enable)

Measurement time	selectable through max. number of data or error bits (max. 2^{31} bits), continuous measurement
Measurement results	BER in ppm (when set number of data or error bits is attained), not synchronized, no clock from DUT
Remote control and memory	via IEC 625-2 (IEEE 488) and RS232
Command set	SCPI 1996.0 with extensions
IEC/IEEE interface functions	SH1, AH1, T6, L4, SR1, RL1, PP1, DC1, DT1, C0
Mass memory	floppy disk drive (3.5", 1.44Mbyte), hard disk 1 Gbyte
Download time	
1 M I/Q samples from built-in hard disk	5.5 s

Differential outputs (option AMIQ-B2) [1]

Provides inverted I and Q signals and allows a DC voltage to be simultaneously superimposed on the output signal.

Outputs	I, $\overline{I}$, Q and $\overline{Q}$
Operating mode	single/differential, selectable
Output impedance	50 Ω when on, 50 Ω or high Z when switched off
Bias voltage (EMC, to ground)	–2.5 V to +2.5 V (±10 mV) for both I and Q channels
	separate, common setting for I and $\overline{I}$ or Q and $\overline{Q}$
Resolution	<1.5 mV
Difference between I and $\overline{I}$ or Q and $\overline{Q}$	<0.5% + 1.5 mV
Output voltage (if not specified otherwise, differential EMF between I and $\overline{I}$ or Q and $\overline{Q}$ outputs)	
Mode fix	2 V, same for both I and Q channels
Level difference I ↔ Q	<0.5% (at 1 kHz, after auto-alignment)
I ↔ $\overline{I}$ (Q ↔ $\overline{Q}$)	<0.5% (at 1 kHz, after auto-alignment)
Residual DC offset	<1 mV (to ground, after auto-alignment)
DC fine variation	typ. ±120 mV
Resolution	120 µV
Variable mode	0 mV to 4 V, separable adjustable for I and Q channels
Resolution	5 digits
DC fine variation	typ. ±280 mV
Resolution	280 µV
Max. output voltage (V_{signal} + V_{bias})	<2.5 V (to ground)

General data

Rated temperature range	0°C to +45°C; meets IEC68-2-1 and IEC68-2-2
Storage temperature range	–40°C to +70°C
Humidity	95% relative humidity at +40°C; meets IEC68-2-3
Vibration, sinusoidal	5 Hz to 150 Hz, max. 2 g at 55 Hz, 0.5 g const. 55 Hz to 150 Hz, meets IEC68-2-6, IEC1010-1 and MIL-T-28800D class 5
Electromagnetic compatibility	meets EN 50081-1 and EN 50082-1 (EMC directive of EU)
Immunity to RFI	10 V/m
Power supply	90 V to 132 V (AC), 47 Hz to 63 Hz, 180 V to 264 V (AC), 47 Hz to 63 Hz, autoranging of AC supply, 150 VA
Safety	meets DIN EN 61010-1, IEC 1010-1, UL 3111-1, CSA 22.2 No. 1010-1
Dimensions (W x H x D)	427 mm x 88 mm x 450 mm
Weight	8.4 kg

WinIQSIM

User interface	Windows interface with context-sensitive help
Systems	single-carrier, multicarrier, multicarrier mixed signal, W-CDMA, IS-95
Single carrier	simulation of digitally modulated single-carrier signals incl. TDMA
Modulation modes	
PSK	BPSK, QPSK, offset QPSK, π/4DQPSK, 8PSK, 8PSK EDGE;
Parameter	reference level = –10 dB to 3 dB PSK rotation = 0 to 15 * π/8
QAM	16/32/64/256QAM
Parameter	Reference level = –10 dB to 3 dB
FSK	MSK, 2FSK, 4FSK, GTFM
Parameter	modulation index = 0.1 to 12 GTFM b = 0 to 1
User-specific modulation	definition of customized modulation modes (PSK, QAM, FSK) via data interface with up to 4.096 mapping states
Baseband filters	Fourier approximation design method with windowing
Digital filters	squarewave √cosine, α = 0.01 to 0.99 cosine, α = 0.01 to 0.99 Gaussian, B·T = 0.1 to 3.0 Gaussian EDGE partial response no filter
User-specific filter	customized filter defined via file interface, specification of impulse response in time domain with up to 1024 coefficients, different filter coefficients for I and Q channel possible
Window	squarewave Hanning Kaiser, β = 0.01 to 10.0 Hamming Chebyshev, ripple = 10 dB to 80 dB
Window length	1 to 32 (integer)
Oversampling	1 to 32 (integer)
Symbol rate	10 sym/s to max. 100 Msym/s
Coding	Gray, Diff, Gray Diff, GSM Diff, NADC, TFTS, MSAT Diff, Phase Diff, none
Data sources	all 0, all 1, PRBS (7, 9, 11, 15, 16, 20, 21, 23), pattern (max. 79 bits), user-defined data sequence via file interface
Data editor	definition of TDMA data structures with modularity at three levels: data field, slot and frame, definition of power-time templates
Data fields	up to 50 different fields, length up to 1000 bits, data content: all 0, all 1, pattern (max. 79 bits) or PRBS
Slots	up to 24 different slots, any combination of up to 36 data fields
Frame	any combination of up to 36 slots
Sequence length	1 to max. 4 Msymbols
Simulation of impairments and transfer characteristics	
I/Q impairment	carrier leakage I and Q (–50 to 50%) I/Q imbalance (–30 to 30%) quadrature offset (–30° to 30°) AM/AM conversion (k2; k3 –3 to 3 dB) AM/PM conversion (k2; k3 –30° to 30°)

[1] All data not specified here are identical to those of AMIQ without option -B2 (I and Q only)

Phase noise	simulation of impairments of phase-locked loop (VCO) and discrete spurious lines
Bandpass	simulation of bandpass at the RF with amplitude and group delay distortion
Amplifier models	amplifiers with soft and hard limiting, nonlinearities: AM/AM k3,k5 –3 to 3 dB; AM/PM k3, k5 –30° to 30°
Power ramping	ramp function: linear, $\cos^2$ rise/fall time: 0 to 16 Tsym level: –80 dB to 0 dB
Multipath propagation	up to 6 paths with different delays, start phases and levels
Offset	phase offset: –180° to 180° frequency offset: –0.35 f_{sample} to 0.35 f_{sample}
Additive impairments	
Noise	E_b/N_0 = –3 dB to 80 dB, bandwidth 0.5/1/2/4/8/16 f_{symbol}
Sinewave interferer	C/I = –3 dB to 80 dB, frequency –0.35 f_{sample} to 0.35f_{sample}
Superimposed signal	addition of a previously calculated signals, level –80 dB to 3 dB
Receiver filters	squarewave √cosine, α = 0.01 to 0.99 Gaussian, B·T = 0.1 to 3.0 user-specific (see above)
Quantization	IQ resolution: 10^{-6} to 0.5; filter coefficient resolution: 10^{-6} to 0.5
Smoothing	smoothing the wraparound of the I/Q signal between signal end and signal start: in range 2 to 32 samples
Graphic output	user-selectable scaling, zoom function, delta marker; display modes: i(t),q(t), r(t), phi(t), r(t), f(t), eye I, eye Q, eye F, vector diagram, constellation diagram, magnitude/phase/group-delay spectrum, additionally CDF and ACP (see below)
CDF function	determination and graphic display of complementary cumulative distribution function with calculation of crest factor
ACP calculation	calculation of adjacent-channel power in the spectrum display (ACP up, low and ACP up 1st alt, low 1st alt)
IF signal generation	modulation of calculated I/Q signal to the IF range 0.01 MHz to 25 MHz (output to I channel of AMIQ)
Multicarrier	simulation of multicarrier signals with same or without modulation
Number of carriers	max. 512 carriers
Parameters of each carrier	status on/off, power, modulation on/off, data source, start phase
Modulation modes	same as with single-carrier system, each carrier can be modulated or not, modulated carriers use the same modulation mode
Baseband filtering	same as with single-carrier system, identical for all modulated carriers
Coding	same as with single-carrier system, identical for all modulated carriers
Data sources	4 different sources, 3 same as in single-carrier system, another PRBS source with different start values for different carriers
Data editor	same as with single-carrier system
Carrier power	–80 dB to 0 dB
Start phase of carrier CW signal	0° to 360° selectable for each carrier or automatic setting for minimizing the crest factor
Sequence length	1 to max. 4 Msymbols
Simulation of impairments and transfer characteristics	same as with single-carrier system, identical for all modulated carriers
Smoothing	same as with single-carrier system
Graphic output	same as with single-carrier system
CDF function	same as with single-carrier system
ACP calculation	same as with single-carrier system
IF signal generation	same as with single-carrier system
Multicarrier mixed signal	simulation of differently modulated multicarrier signals and signals of different systems (Single-carrier, multicarrier, W-CDMA, IS-95) on the carriers
Number of carriers	max. 32
Parameters of each carrier	status on/off, power, I/Q modulation file, start phase
I/Q modulation signal	an I/Q signal file onto which the carrier shall be modulated can be defined for each carrier. These signal files can be generated in all systems.
Carrier power	–80 dB to 0 dB
Start phase of carrier CW signal	0° to 360° selectable for each carrier or automatic setting for minimizing the crest factor
Signal period	automatically adapted to longest or shortest carrier signal period or user-selectable (max. duration 4 Msamples / sample rate)
Graphic output	same as with single-carrier system
CDF function	same as with single-carrier system
ACP calculation	same as with single-carrier system
IF signal generation	same as with single-carrier system
W-CDMA	broadband CDMA acc. to experimental system
Chip rates	
Standard	1.024 Mchips/s, 4.096 Mchips/s, 8.192 Mchips/s, 16.384 Mchips/s
Variable	10 chips /s to max. 100 Mchips /s
Link direction	uplink and downlink
Symbol rates (dedicated PCH)	32, 64, 128, 256, 512, 1024 ksym/s
Code channels	up to 512 depending on chip rate/symbol rate combination
Parameters of each code channel	status on/off, power, symbol rate, short-code number, data, long-code init, long-code offset, data offset
Short code	short-code number selectable for each code channel, spreading factor 4 to 512 depending on symbol rate
Channel power	-80 dB to 0 dB
Sequence length	entry in slots, max. length depending on chip rate and oversampling
Physical channels with frame structure	
1st perch (downlink only)	fixed symbol rate 16 ksym/s, slot fields: pilot, data, LMS
2nd perch (downlink only)	fixed symbol rate 16 ksym/s, slot fields: LMS with editable 32-bit pattern
Common control PCH (64k)	fixed symbol rate 64 ksym/s, slot fields: pilot, data
Dedicated PCH	symbol rates 32, 64, 128, 256, 512, 1024 ksym/s slot fields: pilot, TPC with editable 60-bit pattern, data
Modulation data in slot data fields	4 different data sources, 3 same as with single-carrier system, another PRBS source with different start values for different code channels
Baseband filtering	same as with single-carrier system
Simulation of impairments and transfer characteristics	same as with single-carrier system
Smoothing	same as with single-carrier system
Graphic output	same as with single-carrier system
CDF function	determination and graphic display of complementary cumulative distribution function with calculation of crest factor

ACP calculation	calculation of adjacent-channel power in the spectrum display (ACP up, low and ACP up 1st alt, low 1st alt)
IF signal generation	modulation of calculated I/Q signal to the IF range 0.01 MHz to 25 MHz (output to I channel of AMIQ)
IS-95	CDMA to North-American standard IS-95 A, available as software option AMIQ-K11
Chip rate	
Standard	1.2288 Mchips/s
Variable	10 chips /s to max. 100 Mchips /s
Number of channels	
Forward link	up to 8 complete base stations with 64 code channels each
Reverse link	up to 16 mobile stations
Parameter of each base station	PN offset
Parameters of each code channel	status on/off, power, data, long-code mask
Physical channels of forward link	
Pilot	
Paging	parameter:data, long-code mask with PCN and pilot PN field
Sync	parameter: data
Traffic	parameters: data, long-code mask with permuted ESN field
Physical channels of reverse link	
Access	parameters: data, long-code mask with ACN, PCN, base ID and pilot PN field
Traffic	parameters: data, long-code mask with permuted ESN field
Channel power	–40 dB to 0 dB
Sequence length	entry in symbols, max. length depending on oversampling
Modulation data	4 different data sources, 3 same as with single-carrier system, another PRBS source with different start values for different code channels
Baseband filtering	same as with single-carrier system
Simulation of impairments and transfer characteristics	same as with single-carrier system
Smoothing	same as with single-carrier system
Graphic output	same as with single-carrier system
CDF function	determination and graphic display of complementary cumulative distribution function with calculation of crest factor
ACP calculation	calculation of adjacent-channel power in spectrum display (ACP up, low and ACP up 1st alt, low 1st alt)
IF signal generation	modulation of calculated I/Q signal to IF in the range 0.01 MHz to 25 MHz (output to I channel of AMIQ)

Miscellaneous	
Trace transmission to AMIQ	interfaces: IEC/IEEE bus (GPIB), RS-232, floppy; conversion of I/Q signal to 14-bit AMIQ format: user-selectable clipping level (over- and underranging possible)
Remote control of AMIQ	download and starting of traces, hardware configuration, alignment and fine adjustment, file management, BER test
For data transfer	IEC/IEEE bus (GPIB): card (from National Instruments) with drivers, IEC/IEEE-bus cable; RS-232: null-modem cable
System requirements	PC compatible to industry standard, CPU clock min. 100 MHz, Win 3.x with 32 Mbyte RAM, Win 95 with 32 Mbyte RAM or Win NT with 48 Mbyte RAM recommended, at least 30 Mbyte hard disk memory, mouse, monitor: 1024 x 768 pixels with 256 colours recommended

Ordering information

I/Q Modulation Generator	AMIQ	1110.2003.02
Accessories supplied: WinIQSIM, version for Windows 3.x and Windows 95/NT on 3.5" disks, manual, power cable, operating manual AMIQ		
Options		
BER Measurement	AMIQ-B1	1110.3500.02
Differential I/Q Outputs	AMIQ-B2	1110.3700.02
Rear I/Q Outputs	AMIQ-B19 [1]	1110.3400.02
IS-95 CDMA	AMIQ-K11	1122.2003.02
Recommended extras		
19" Rack Adapter	ZZA-211	1096.3260.00
Service manual AMIQ		1110.3339.21

[1] Marker outputs 3 and 4 not provided when this option is fitted (not with option AMIQ-B2)

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ROHDE & SCHWARZ

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Safety Instructions

This unit has been designed and tested in accordance with the EC Certificate of Conformity and has left the manufacturer's plant in a condition fully complying with safety standards.

To maintain this condition and to ensure safe operation, the user must observe all instructions and warnings given in this operating manual.

Safety-related symbols used on equipment and documentation from R&S:

Observe operating instructions

Weight indication for units >18 kg

PE terminal

Ground terminal

Danger! Shock hazard

Warning! Hot surfaces

Ground

Attention! Electrostatic sensitive devices require special care

1. The unit may be used only in the operating conditions and positions specified by the manufacturer. Unless otherwise agreed, the following applies to R&S products:

   IP degree of protection 2X, pollution severity 2 overvoltage category 2, only for indoor use, altitude max. 2000 m.

   The unit may be operated only from supply networks fused with max. 16 A.

   Unless specified otherwise in the data sheet, a tolerance of ±10% shall apply to the nominal voltage and of ±5% to the nominal frequency.

2. For measurements in circuits with voltages V_{rms} > 30 V, suitable measures should be taken to avoid any hazards.

   (using, for example, appropriate measuring equipment, fusing, current limiting, electrical separation, insulation).

3. If the unit is to be permanently wired, the PE terminal of the unit must first be connected to the PE conductor on site before any other connections are made. Installation and cabling of the unit to be performed only by qualified technical personnel.

4. For permanently installed units without built-in fuses, circuit breakers or similar protective devices, the supply circuit must be fused such as to provide suitable protection for the users and equipment.

5. Prior to switching on the unit, it must be ensured that the nominal voltage set on the unit matches the nominal voltage of the AC supply network.

   If a different voltage is to be set, the power fuse of the unit may have to be changed accordingly.

6. Units of protection class I with disconnectible AC supply cable and appliance connector may be operated only from a power socket with earthing contact and with the PE conductor connected.

7. It is not permissible to interrupt the PE conductor intentionally, neither in the incoming cable nor on the unit itself as this may cause the unit to become electrically hazardous.

   Any extension lines or multiple socket outlets used must be checked for compliance with relevant safety standards at regular intervals.

8. If the unit has no power switch for disconnection from the AC supply, the plug of the connecting cable is regarded as the disconnecting device. In such cases it must be ensured that the power plug is easily reachable and accessible at all times (length of connecting cable approx. 2 m). Functional or electronic switches are not suitable for providing disconnection from the AC supply.

   If units without power switches are integrated in racks or systems, a disconnecting device must be provided at system level.

9. Applicable local or national safety regulations and rules for the prevention of accidents must be observed in all work performed.

   Prior to performing any work on the unit or opening the unit, the latter must be disconnected from the supply network.

   Any adjustments, replacements of parts, maintenance or repair may be carried out only by authorized R&S technical personnel.

   Only original parts may be used for replacing parts relevant to safety (eg power switches, power transformers, fuses). A safety test must be performed after each replacement of parts relevant to safety.

   (visual inspection, PE conductor test, insulation-resistance, leakage-current measurement, functional test).

continued overleaf

10. Ensure that the connections with information technology equipment comply with IEC950 / EN60950.
11. Lithium batteries must not be exposed to high temperatures or fire.

    Keep batteries away from children.

    If the battery is replaced improperly, there is danger of explosion. Only replace the battery by R&S type (see spare part list).

    Lithium batteries are suitable for environmentally-friendly disposal or specialized recycling. Dispose them into appropriate containers, only.

    Do not short-circuit the battery.
12. Equipment returned or sent in for repair must be packed in the original packing or in packing with electrostatic and mechanical protection.
13. Electrostatics via the connectors may damage the equipment. For the safe handling and operation of the equipment, appropriate measures against electrostatics should be implemented.
14. The outside of the instrument is suitably cleaned using a soft, lint-free dustcloth. Never use solvents such as thinners, acetone and similar things, as they may damage the front panel labeling or plastic parts.
15. Any additional safety instructions given in this manual are also to be observed.

Certified Quality System

ISO 9001

DQS REG. NO 1954-04

Sehr geehrter Kunde,

Sie haben sich für den Kauf eines Rohde & Schwarz-Produktes entschieden. Hiermit erhalten Sie ein nach modernsten Fertigungsmethoden hergestelltes Produkt. Es wurde nach den Regeln unseres Qualitätsmanagementsystems entwickelt, gefertigt und geprüft. Das Rohde & Schwarz-Qualitätsmanagementsystem ist nach ISO 9001 zertifiziert.

Dear Customer,

You have decided to buy a Rohde & Schwarz product. You are thus assured of receiving a product that is manufactured using the most modern methods available. This product was developed, manufactured and tested in compliance with our quality management system standards.
The Rohde & Schwarz quality management system is certified according to ISO 9001.

Cher client,

Vous avez choisi d'acheter un produit Rohde & Schwarz. Vous disposez donc d'un produit fabriqué d'après les méthodes les plus avancées. Le développement, la fabrication et les tests respectent nos normes de gestion qualité.
Le système de gestion qualité de Rohde & Schwarz a été homologué conformément à la norme ISO 9001.

ROHDE & SCHWARZ

ROHDE&SCHWARZ

EC Certificate of Conformity

CE

Certificate No.: 98034

This is to certify that:

Equipment type	Order No.	Designation
AMIQ	1110.2003.02/.03/.04	I/Q Modulation Generator
AMIQ-B2	1110.3700.02	Differential I/Q Outputs
AMIQ-B3	1122.2103.02	Digital I/Q Output
AMIQB19	1110.3400.02	I/Q Rear Panel Connection

complies with the provisions of the Directive of the Council of the European Union on the approximation of the laws of the Member States

- relating to electrical equipment for use within defined voltage limits (73/23/EEC revised by 93/68/EEC)
- relating to electromagnetic compatibility (89/336/EEC revised by 91/263/EEC, 92/31/EEC, 93/68/EEC)

Conformity is proven by compliance with the following standards:

EN61010-1 : 1993 + A2 : 1995
EN50081-1 : 1992
EN50082-2 : 1995

Affixing the EC conformity mark as from 1998

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Munich, 1999-09-17

Central Quality Management FS-QZ / Becker

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Contents of Manuals for I/Q Modulation Generator AMIQ

Operating Manual

The operating manual consisting of a data sheet and 10 chapters contains comprehensive information on characteristics, putting into operation, operation and remote control of AMIQ:

The data sheet informs about guaranteed specifications and characteristics.

Chapter 1 describes the operating principle of AMIQ, control elements and connectors on the front and rear panel as well as all procedures required for putting the instrument into operation and integration into a test system.

Chapter 2 details instrument control via the remote interfaces with the aid of program examples.

Chapter 3 presents control and display elements.

Chapter 4 describes key operating modes and special characteristics of AMIQ with reference to possible applications.

Chapter 5 describes programming of AMIQ, command processing, status reporting system and characteristics of hardware interfaces.

Chapter 6 describes the remote-control commands defined for the instrument. At the end of the chapter an alphabetical list of commands is given.

Chapter 7 contains program examples for a number of typical applications of AMIQ.

Chapter 8 describes preventive maintenance.

Chapter 9 gives hints on troubleshooting and contains a list of error messages.

Chapter 10 contains an index for the operating manual.

Service Manual

The service manual informs on how to check compliance with rated specifications, on instrument function, repair, troubleshooting and fault elimination. It contains all information required for the maintenance of AMIQ by exchanging modules.

The service manual also contains the circuit documentation for the module "IQ Analog/Digital Unit".

1 Putting into Operation

Introduction

Task

AMIQ is a modulation source for complex baseband signals of state-of-the-art telecommunication networks. Two synchronous outputs, which are matched to each other, and a large memory together with wide analog bandwidth make AMIQ suitable for universal use.

AMIQ has been designed to generate I and Q signals in the baseband for present and future types of modulation. "I" stands for the in-phase component, "Q" for the quadrature component.

Operating principle

The data to be output by AMIQ are normally calculated by an external workstation (eg PC). To control this calculation, Rohde & Schwarz offers two programs: WINIQSIM and AMIQ Control, a software for R&S vector signal generator SMIQ (see Section "Software for AMIQ Control on page 1.8"). The desired information data stream (eg a piece of speech) is generated and a modulation mode selected. Then various interference and distortions (so-called impairments) are superimposed to this (ideal) baseband signal. Thus a long sequence of sample values is obtained, which are loaded into AMIQ (via floppy, IEC/IEEE bus or RS-232 interface). The sequence in the AMIQ memory is then output as analog I and Q signals with the aid of fast and accurate D/A converters. The outputs are (normally) connected to the modulation inputs of an I/Q modulator (eg SMIQ), which modulates the baseband signal onto the desired RF (Fig. 1-1).

Transmission error

The RF signal is transmitted via the antenna to the receiver where it is converted back into information data. On the transmission link, errors may be caused in the information data stream by coding, impairments and decoding. These errors can be detected with the aid of option AMIQ-B1 (BER measurement) and evaluated.

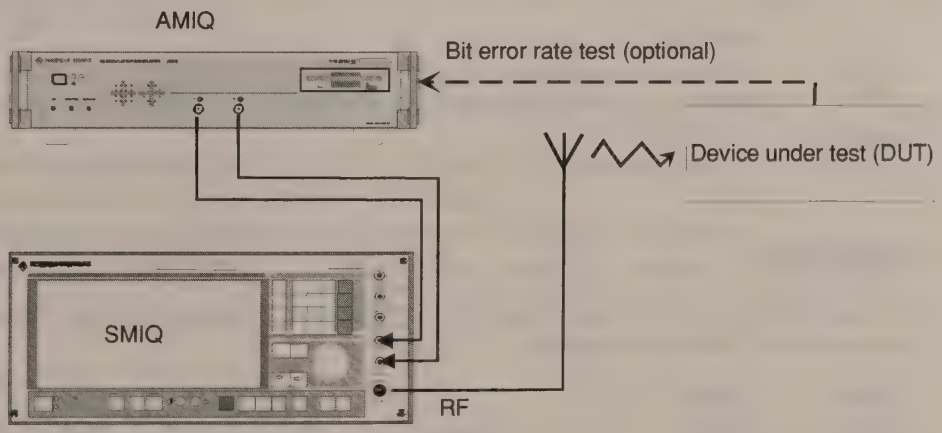


Fig. 1-1 AMIQ used in a test setup

Test setup

The four additional marker outputs and a trigger input simplify integration in a test setup. The user-selectable positions of the marker switch points permit external, variable amplifiers (eg for power ramping) or signalling facilities to be controlled.

Front and Rear View

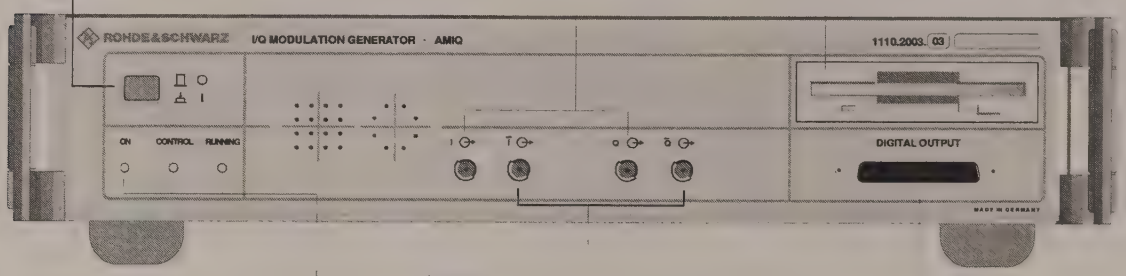
Power switch

preset in as long
as Instrument is on

I In-phase component
Q Quadrature component
☞ Chapter 1 "Introduction"

3,5"-disk drive

Refer to "Installation of Options"
in chapter 1 when exchanging
data and instrument software



3 LEDs indicating the instrument status

Additional outputs T and Q with option
Differential I/Q Outputs installed

Option Digital I/Q Output AMIQ-B3

ON AMIQ ready for operation
CONTROL Remote control active
RUNNING Waveform in output memory in triggered

☞ Chapter 1
"Power up / Switch-onTest"

Fig. 1-2 AMIQ Front view

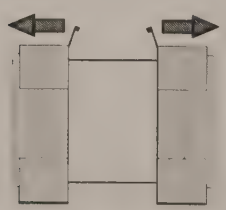
Putting into Operation

Caution!

The following instructions should be strictly observed, in particular when putting the instrument into operation for the first time, to avoid damage to the instrument and hazards to persons.

Unpacking

After unpacking the instrument, check for completeness according to the delivery note and the accessory lists for the individual items.



Remove protective covers

Remove the two protective covers from the front and rear of the AMIQ and carefully check the instrument for any damage. In case of any damage you should immediately inform the responsible transport agent and keep all packing material not to forfeit your claims.

The original packing should also be used for any later transport or shipment of AMIQ. You should keep at least the two protective covers for the front and rear of the instrument.

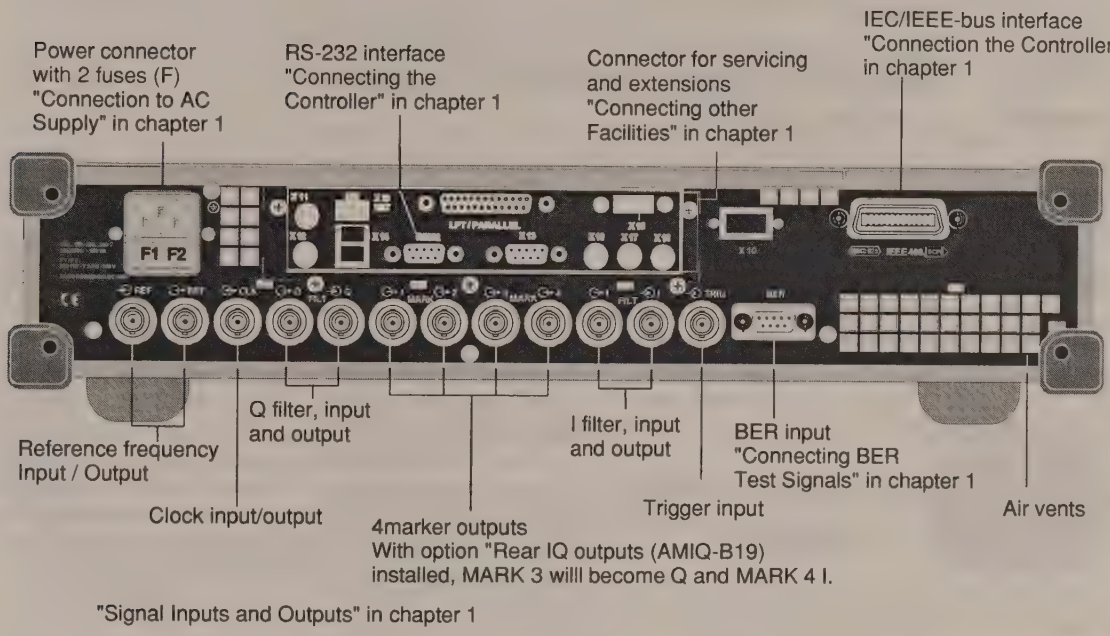


Fig. 1-3 AMIQ rear view

Setting Up

Permissible setup positions for AMIQ:

- Flat.
- Upright standing on its rear. In this case an angular AC supply connector should be used.

Note: *To ensure problem-free operation of the instrument the following should be observed:*

- *Do not obstruct air vents at the rear and sides.*
- *Observe the permissible ambient temperature specified in the data sheet.*
- *Avoid condensation. Allow instrument with condensation to dry before switching on.*

Rackmounting

Adapter ZZA-211 (Order No. 1096.3260.00) allows the AMIQ to be mounted in 19" racks. Rackmounting is described in the installation instructions of the rack adapter.

For rackmounting it is recommended to fit the option AMIQB19 (I/Q Rear-Panel Connection) (Order No. 1110.3400.02), which changes I and Q connectors from the front to the rear.

Note: *To ensure problem-free operation of the instrument the following should be observed:*

- *Provide for sufficient air flow in the rack.*
- *Make sure that there is sufficient space between air vents and rack.*

Connection to AC Supply

Caution!

Allow instrument with condensation to dry before switching on.

Observe permissible ambient temperatures -10°C to +45°C.

Do not cover up air vents.

AMIQ may be connected to a single-phase AC supply with a rated voltage from 100 V to 240 V and rated frequency from 50 Hz to 60 Hz.

Note: *AMIQ automatically sets itself to the local AC supply voltage. There is no need for external switchover or exchanging fuses.*

← AC supply connector

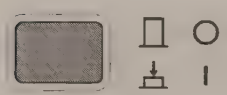
← Power fuses

Use the power cord supplied with the AMIQ for connection to the AC supply. Since the AMIQ is designed in line with protection class I requirements to EN61010 it may only be connected to an earthing-contact type connector. As soon as the connection has been established, AMIQ outputs a beep and the ON LED lights with slightly reduced brightness. After the start-up is completed, the ON LED is fully on.

Power Fuses

AMIQ is fully fused by two fuses IEC127-T4.0H/250 V. The fuses are accommodated in the pull-out fuse holder below the power connector. Before replacing the fuses, disconnect the power cord from the AMIQ. Use a screwdriver to lift the fuse holder below the power connector and pull it out. Use only fuses of the above type.

Power Up / Switch-on Test



➢ Press switch-on key on the AMIQ front panel.

Note: *No floppy should be in the drive when AMIQ is switched on. If this happens nonetheless, one of the actions stored on the floppy may be executed (see sections "New installation of AMIQ software" and "Changing the IEC/IEEE-bus address in this chapter).*

Start-up procedure

After power-up the system is started, the controller short test is performed and the operating system DOS and the remote-control software are loaded from the integrated hard disk. During this time the ON LED lights with reduced intensity.

Test of controller hardware

First the switch-on test for the integrated controller is performed. Since at this stage the LEDs are not driven, no information can be obtained on the device status. If a fault occurs, AMIQ outputs a sequence of beeps, the meaning of which can be seen in the enclosed main board manual. If a fault occurs, the switch-on procedure is normally aborted.

Short test of functional hardware

The AMIQ hardware is then set to operating state and tested. Any error is signalled by two short successive beeps provided the built-in loudspeaker was not switched off with the IEC/IEEE-bus command `:SYST:BEEP:STAT OFF`. At the end of the selftest a single beep is output. After this the instrument is ready for operation.

Further information on error can be obtained by a repeated readout of the error queue using IEC/IEEE-bus queries `:SYST:ERR?`.

Even if an error occurs, the switch-on procedure is in most cases continued so that the error queue can be read out. The instrument may not be fully functional however.

LEDs after the short test

If an error is detected in the short test, the ON LED flashes.

With the short test completed successfully, the last active setup is automatically loaded from the hard disk and the instrument is set to the operating status before switch-off. The currently selected waveform is loaded together with this complete setup. For a curve with 4.000.000 samples and with AMIQ 03, this may take up approx. 20 seconds. With AMIQ 04 and its quadrupled memory capacity, the loading time increases to approx. 80 s.

If no further errors occurred, the ON and the CONTROL LEDs briefly light. Afterwards, the ON and RUN LEDs come fully on.

Error messages

If an error is detected the error message is entered in plain text into the error queue of AMIQ and ON LED flashes. This is why after restart the AMIQ control program in the host computer should read out the error queue by means of the command `SYST:ERR?` until it is empty, i.e., until the entry `0,"No Error"` is read. Depending on the error detected, AMIQ will usually respond to commands transmitted via IEEE-bus or RS-232 interface but may not be fully functioning. The ON LED lights steadily at full brightness.

Note

If ON LED flash fast, it is only a hint that AMIQ does not generate any curve at the moment. It appears whenever a curve was stored directly to the AMIQ's SDRAM to save time before switching off AMIQ by means of the `MEM:DATA RAM, <binary block data>` *command (e.g. with WinIQSIM via the settings* ***Transmission****,* ***Force internal****,* ***Destination AMIQ-RAM****). This can be suppressed by loading curves via a waveform file using the command* `MMEM:LOAD RAM, 'filename.WV'` *; such a curve is available immediately after switching on the instrument.*

- If AMIQ does not start as described above, check the AC supply connection and, if required, replace the two power fuses (see section "Power fuses" in this chapter).
- A complete selftest of AMIQ's hardware components can be started with the common command `*TST?`. Furthermore, the command `DIAG:SELF:SDRAM?` can be used to test the whole SDRAM of AMIQ in detail, see Sections „Common Commands“ and „DIAGnostic – Hardware Diagnosis“ in Chapter 6.

Instrument Switch-off

- Wait until the hard disk or the floppy disk drive are no longer accessed
- Remove floppy from the disk drive
- Press power switch on the front panel. All instrument settings are retained.

EMC Shielding Measures

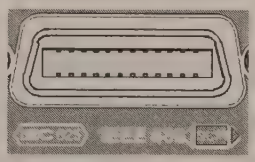
To avoid electromagnetic interference, the instrument must always be closed when in operation. Use only appropriate, shielded signalling lines and control cables. Particularly the line connected to the clock output should be double-shielded and terminated.

Connection to Test Setup

Connecting the Controller

AMIQ has no user interface of its own. An external controller is therefore required for operating AMIQ which can be performed in two ways:

Connection via IEC/IEEE bus



AMIQ is simply connected to the IEC/IEEE bus. Upon delivery the bus address is 6. If the bus address has been changed, e.g. by a previous control command, or if the bus address has to be changed, proceed as described in section "Changing the IEC/IEEE-bus address" on page 1.7.

Connection via the serial interface

AMIQ is connected to the serial interface of a PC by means of a null modem cable. Connect the cable to the 9-contact sub-D connector of the AMIQ labeled RS232. Use the COM1 or COM2 connector of the PC which may be a 25-contact or 9-contact connector. Suitable adapters may have to be used.

Serial interface

The serial interface is configured for 9600 Baud, 8 data bits, no parity. When the WinIQSIM software is used, which is recommended by R&S, the interface of the PC is automatically configured with the AMIQ settings. However, the interface used has to be set in the menu first.

Pin assignment and wiring of the null modem cable are described in section "Handshake" of chapter 5.

Changing the IEC/IEEE-bus Address

Upon delivery the instrument is set to address 6. If for any reason this address is not available, the setting can be changed as follows:

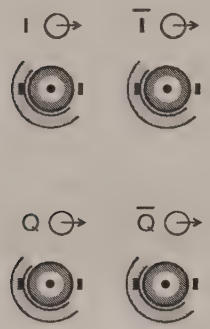
- Generate a file on a PC, which contains only the following line:
  `:SYST:COMM:GPIB:ADDR x`
  with `x` being the desired address. Add an empty line.
- Copy this file under the name AUTOEXEC.IEC into the main memory of a 3.5" floppy.
- Insert the floppy in the AMIQ, switch AMIQ off and on again.

Software for AMIQ Control

AMIQ can only be remote-controlled. To simplify operation, Rohde & Schwarz offers two different software programs for the control of AMIQ:

- WinIQSIM: This software permits calculation of complex I/Q signals, controls the transfer of these signals to the AMIQ via IEEE-bus or RS-232 interface and determines how the signals are output.
- AMIQ control software menu for SMIQ: In this case AMIQ is controlled from SMIQ. Control is similar to that of the SMIQ options but I/Q signals cannot be generated. It is possible, however, to load I/Q signals that have been generated on an external PC.

Signal Inputs and Outputs



Analog I/Q output:

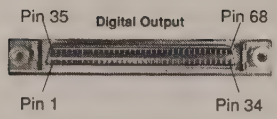
The loaded waveforms are output at two BNC connectors I and Q on the front panel (four BNC connectors I and $\overline{I}$, Q and $\overline{Q}$ if option Differential Outputs (AMIQ-B2) is fitted). The output is determined by the trigger conditions and depends on the applied trigger signals (see section "Triggering" in chapter 4). If the trace output is not active, an idle-channel signal is output (see section "ARM/TRIGger/ABORt - Triggering, Sequence control" in chapter 6).

If option AMIQ-B2 is not fitted the I/Q outputs on the front panel can be taken to the rear with option I/Q Rear-Panel Connection (AMIQB19). This simplifies wiring particularly when the AMIQ is rack-mounted.

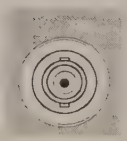
Note: *When the I/Q outputs are taken to the rear, marker outputs 3 and 4 (BNC connectors) are used. This means that marker outputs 3 and 4 are no longer available.*

*Upon delivery and after an *RST, the I and Q outputs are switched off. Use commands* `OUTPUT:I FIX` *and* `OUTPUT:Q FIX` *to reactivate the channels.*

Digital I/Q output:

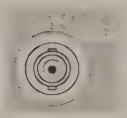


Option AMIQ-B3, Digital I/Q Output, provides the 16 bit wide data bus for both I and Q channels via a 68-pole SCSI socket at the front panel of the AMIQ. See section "Option "Digital I/Q Output AMIQ-B3" below.



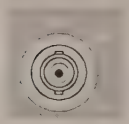
Trigger input (TRIG):

Rear BNC connector (female). The output of the stored waveform can be started or enabled with a TTL signal applied to this connector. Trigger condition and polarity are user-selectable.



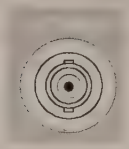
Marker outputs (MARK):

Four BNC connectors (female) at the rear. These outputs (TTL level, can be terminated with 50 Ω) are used for the control of further instruments, e.g. an oscilloscope or variable amplifiers (power ramping). (See "Marker outputs" in chapter 4).



I/Q filter (input and output):

Here an external passband filter (e.g. for anti-aliasing) can be looped in for the I and Q path instead of the internal filters. The outputs have a nominal impedance of 50 Ω and yield a peak voltage of 0.5 V into 50 Ω when driven at full scale. The filter attenuation in the passband range should be 0 dB.



Reference clock input (REF):

Input for an external 10 MHz reference clock; V_{rms} = 0.1 V to 2 V, input impedance 50 Ω.

Reference clock output (REF):

Output of 10 MHz reference clock; V_{rms} = 0.5 V, output impedance 50 Ω.

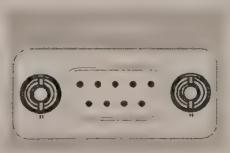
Clock input/output (CLK):

Output with the actual clock rate; V_{rms} = 0.5 V, output impedance 50 Ω. Input for external clock (TTL signal).

Caution!

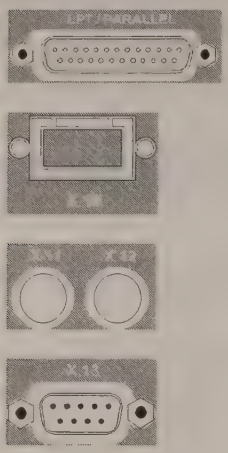
Because of the high clock rates at the clock output, a double-screened cable should be used to keep within permissible EMI limits. The line should in all cases be terminated with 50 Ω.

Connecting BER Test Signals



AMIQ comprises a programmable facility for bit error rate (BER) measurements. The required signals have to be applied to the AMIQ via the BER input with TTL level. The signals to be applied depend on the test method used and are described in the manual for option AMIQ-B1 (see section "BER measurement" in chapter 4).

Connecting other Facilities



The connectors labeled *LPT/PARALLEL, X10, X11, X12* and *X13* are used for servicing or for extensions.

Note: *In normal operation these connectors must be open.*

Installation of Options

The following options are available for AMIQ:

BER Measurement	AMIQ-B1	1110.3500.02
Differential I/Q Outputs	AMIQ-B2	1110.3700.02
Digital I/Q Output	AMIQ-B3	1122.2103.02
Rear I/Q Outputs	AMIQB19	1110.3400.02
IS-95 CDMA	AMIQK11	1122.2003.02
CDMA 2000	AMIQK12	1122.2503.02
Not assigned	AMIQK13	
TD-SCDMA	AMIQK14	1122.2703.02
OFDM Signal Generation	AMIQK15	1122.2803.02

AMIQ is supplied with the options already fitted. For a subsequent installation of options refer to the fitting instructions supplied with the options or refer to chapter 4 of the Service Manual.

Software options AMIQ-B1, AMIQK11, AMIQK12, AMIQK13, AMIQK14 and AMIQK15 can be installed by the customer. No extra test equipment is needed for the installation.

Installation of a software option is described at the end of chapter 4 using AMIQ-B1 as an example.

In order to fit one of the hardware options AMIQ-B2, AMIQ-B3 or AMIQB19 the casing of the instrument must be opened. This will break the calibration seal so that the calibration is no longer valid. Therefore, these options should be installed by an R&S service representative.

Important: *The components used in the instrument are sensitive to electrostatic charges and should therefore be handled according to ESD regulations.*

Option AMIQ-B1, BER Test

AMIQ-B1 is a software option which can be installed without opening the instrument. For the installation proceed as described in the instructions supplied with the option.

For a description of the BER test refer to chapter 4.

Option AMIQ-B2, Differential I/Q Outputs

To fit this hardware option the instrument must be opened. Therefore, it must be retrofitted by an authorized service representative. Control of the differential outputs of AMIQ by means of WinIQSIM is supplied starting with version 2.10 of both products.

For an application example for option Differential Outputs refer to chapter 4.

Option AMIQ-B3, Digital I/Q Output

Retrofitting the hardware option AMIQ-B3 requires the instrument to be opened. Therefore, it must be done by an authorized service representative. The Digital I/Q Output can be controlled by WinIQSIM version 3.10 and higher.
An application example for option Digital I/Q Output is given in chapter 4.

Option AMIQB19, I/Q Rear-Panel Connection

This option can be fitted only if option Differential Outputs (AMIQ-B2) is not installed. Retrofitting the option requires the instrument to be opened. Therefore, this must be done by an authorized service representative. With option AMIQB19 fitted, marker outputs 3 and 4 are no longer available as these connectors are used as Q and I signal outputs (i.e. the I output is connected to marker output 4, the Q output is connected to marker output 3).

Option AMIQK11, IS-95 CDMA

Software option for interpreting a waveform file generated according to IS95 by WinIQSIM, version 2.10 or higher. The option is enabled by means of a key number so that the instrument doesn't have to be opened. Proceed as described in the instructions supplied with the option.

Option AMIQK12, CDMA 2000

Software option for interpreting a waveform file generated in WinIQSIM vers. 3.20 according to CDMA 2000. There is no need to open the instrument as the option is enabled by by means of a key number. Proceed as described in the instructions supplied with the option.

Option AMIQK14, Digital Standard TD-SCDMA

TD-SCDMA (time-division synchronous CDMA) designates a mobile-radio transmission method developed by the China Wireless Telecommunication Standard Group (CWTS, http://www.cwts.org). This standard is similar to the 3GPP TDD proposal, but with greater emphasis placed on GSM compatibility and with a chip rate limited to 1.28 Mcps.

Option AMIQK15, OFDM Signal Generation

Software option for interpreting a waveform file generated in **WinIQOFDM** with the aid of WinIQSIM™ Vers. 3.40. Special emphasis is placed on the generation of signals conforming to HIPERLAN/2 or IEEE 802.11a (**WinIQOFDM** is a PC software that generates OFDM-modulated signals from binary data streams, these signals are then read by WinIQSIM via the DDE interface for further processing).

Initial Installation or Update of AMIQ Software

For initial installation of the AMIQ software, a program disk (3.5") is needed. The disk is available from your local sales engineer. It usually contains two files: AMIQxxx.DAT and README.TXT. "xxx" stands for the firmware version number; AMIQ304.DAT means firmware version 3.04, for example. In AMIQxxx.DAT, over 40 files required for the firmware update are packed in compressed form.
Insert the disk into the AMIQ floppy disk drive. Then switch the unit off and on again. On switch-on, the unit automatically checks whether an update disk is inserted in the drive. If this is the case, the complete new firmware is loaded from the disk. The download takes approx. 4 minutes and is indicated by a green LED on the floppy disk drive. When the LED goes out, AMIQ is ready for operation.

In the event that the firmware is not loaded, a fault may be in the controller which can only be eliminated with the aid of a graphics card (ISA or PCI bus) when the instrument is open and a keyboard is connected (see Service Manual).

2 Getting Started

AMIQ can only be remote-controlled. For this purpose a serial interface RS-232, an IEC/IEEE-bus interface and the disk drive are available. This chapter gives a brief introduction to instrument operation via these interfaces. Typical applications, characteristics and operating modes of AMIQ will be described in chapter 4.

Control via Serial Interface

AMIQ can be connected to the serial interface of a PC via the rear, 9-contact sub-D connector labeled RS 232.

Setting example:

With the following steps, a 100 kHz sinusoidal signal is obtained at the outputs of AMIQ.

- Connect instrument and controller by means of the null modem cable (see section "Connecting the Controller" in chapter 1, for pin assignment of null modem cable see "Handshake" in chapter 5).
- Set the serial interface at the controller to 9600 Baud, no parity, 8 bit, 1 stop bit.

Example: To configure the controller interface enter the following command under DOS:

```
mode com<x>: 9600, n, 8, 1
```

<x> = 1 or 2 depending on connector used.

- Create the following ASCII file at the controller:

```
                                  (empty line) Sets instrument to remote control
*RST;*CLS;*WAI                    Resets the instrument
*RCL 'SINUS'                      Outputs stored trace
                                  (empty line)
```

- Transfer this ASCII file to the instrument via the RS-232 interface. Enter the following command at the controller:

```
copy <file name> com<x>:
```

A frequency of 100 kHz is now available at the outputs of the instrument, as this setting is stored under `SINUS`.

Note: *Upon delivery and after an *RST the I and Q output are switched off. Use commands* `OUTPUT:I FIX` *and* `OUTPUT:Q FIX` *to activate the outputs.*

DOS commands are used for all settings via the serial interface. The use of a terminal emulation program considerably simplifies handling of the serial interface. Since these programs greatly differ, no instructions are given here for their use.

Simple terminal programs are for instance available on the Internet, e.g. under
`http://www.leo.org/archiv/msdos/` *or*
`ftp://garbo.uwasa.fi/pc`

Changing the transmission rate:

The instrument is set in the factory to a baud rate of 9600 bps and hardware handshake via RTS and CTS lines. The handshake procedure cannot be changed. When the baud rate is changed or if another rate is required, the rate can be modified as follows:

➢ Create a file with the name AUTOEXEC.IEC in the main directory of a 3.5" floppy. Write the following lines into this file:

```
:SYST:COMM:SER:BAUD 9600
```

and replace 9600 by the baud rate desired (for permissible values see description of command :SYST:COMM:SER:BAUD).

➢ Switch off AMIQ, insert the file and start AMIQ.

Upon the start the created file is read and the baud-rate setting command executed.

Control via IEC/IEEE-Bus Interface

The AMIQ can be connected to the IEC/IEEE bus via the rear IEEE 488 connector (see section "Connecting the Controller" in chapter 1).

Setting example:

With the following control steps a 100 kHz sinusoidal signal is obtained at the outputs of AMIQ.

➢ Connect instrument and controller by means of an IEC/IEEE-bus cable.

Note: *The instrument is set in the factory to the IEC/IEEE-bus address 6. If this address has been changed or is not available (e.g. because it is used by another instrument), the address can be changed as described in section "Changing the IEC/IEEE-bus Address" in chapter 1.*

➢ Create and start the following program at the controller:

`CALL IBFIND("DEV1", amiq%)`	Opens channel to the instrument
`CALL IBPAD(amiq%, 6)`	Specifies device address at the controller
`CALL IBWRT(amiq%, "*RST;*CLS;*WAI")`	Resets instrument
`CALL IBWRT(amiq%, "*RCL 'SINUS'")`	Outputs trace (stored in the instrument upon delivery)

A 100 kHz sinewave signal is now available at the outputs of AMIQ.

Control via Floppy

Purpose

In addition to the control capabilities described above, AMIQ can also be controlled via a file in the disk drive. This control function is however not intended for continuous operation but for executing functions (e.g. setting the baud rate or IEC/IEEE-bus address) that are not accessible during normal operation. (see "Control via Serial Interface").

Function

On power-up a check is made whether a floppy is in the disk drive and whether this file contains an A:\ PWRUP.IEC file. If this is the case the remote-control commands in this file are executed one after the other. The syntax is identical to that used on the IEC/IEEE bus or at the serial interface.

Execution of program files

The execution of program files can be triggered any time with command `PROG:EXEC 'name'` (which has to be transferred via one of the other remote-control sources). The called program file is searched for first on the floppy, then on the hard disk.

Switchover between Remote-Control Interfaces

After power up all remote-control sources (serial interface, IEC/IEEE bus) are active. When the instrument receives a command on one of the two interfaces, the *REMOTE* LED is switched on and the other interface is deactivated. To be able to use the other interface different procedures can be chosen:

- Switch the instrument off and on again
- Send command `*GTL` via the serial interface if the latter is active.
- Send the message `IBLOC(amiq%)` via the IEC IEEE bus if the latter is active.

After the commands in a batch file have been executed, the instrument returns to the previous remote control mode.

3 Operation

Control Elements

AMIQ has no manual control elements except for the power on/off key. The I and Q signal outputs, the 3.5" disk drive and 3 LEDs are available on the front panel.

AMIQ is remote-controlled (see chapter 6).

I/Q signals can be simply and flexibly generated via the WinIQSIM program. AMIQ can also be controlled from Vector Signal Generator SMIQ (see section "Calculation of I/Q Modulation Signals" below).

Indicating Elements (LEDs)

Three LEDs are provided on the AMIQ front panel with the following functions:

ON Is dimmed during the short test and lights fully during normal operation. The ON-LED flashes slowly while a data set is loaded into the AMIQ; it flashes quickly if an error occurred during the short test on power-up. Further information on the error can be obtained with `:SYST:ERR?`.

CONTROL Lights when the host controller has switched the AMIQ to remote control. Flashes during long data transmissions. The remote-control source can only be changed (e.g. from IEC/IEEE bus to RS-232) when this LED is off. See also command `*GTL`.

RUNNING Lights as soon as and as long as AMIQ reads data from the output memory and outputs them at the I and Q output sockets.

Calculation of I/Q Modulation Signals

Control via WinIQSIM

WinIQSIM

The simplest and most flexible way to generate I/Q signals is to use the WinIQSIM program from Rohde & Schwarz. This program can be installed on a PC. The user interface permits convenient generation of the desired modulation waveforms and the corresponding control of AMIQ.

IEC/IEEE bus / RS-232

- AMIQ can be controlled from the PC with WinIQSIM in two different ways:
- Via a state-of-the-art IEEE-488 interface which can be controlled via an installed WINDOWS® operating system (GPIB.DLL required).
- Via the RS-232 interface. However, the data transmission rate here is lower than with control via the IEC/IEEE bus.

Control via Vector Signal Generator SMIQ

SMIQ

If SMIQ is the RF source for vector-modulated signals, AMIQ can be controlled from SMIQ. An additional controller is not required in this case.

Settings

All main settings of AMIQ can be made in the *AMIQ CTRL* menu. The individual menu items are described in the SMIQ manual.

4 Functional Description

Uses

Application

AMIQ is mainly used for generating modulation signals for the I and Q inputs of a vector-modulated RF generator. Another application is testing modules or components with an I/Q interface. The control of I/Q interfaces is particularly simplified by fine tuning the delay, level and offset of the I/Q outputs. With this adjustment non-ideal characteristics of the circuits to be driven can be compensated for.

Apart from the use as an I/Q signal source AMIQ allows all kinds of signals of programmable waveform to be generated at the I/Q outputs and at the four digital marker outputs of the instrument.

Design

AMIQ basically consists of a two-channel D/A converter and an output SDRAM for 4,000,000 samples (AMIQ model 03) or 16,000,000 samples (AMIQ model 04). The D/A converter clock can be adjusted in the wide range 10 Hz to 105 MHz. The technical data, however, are valid up to 100 MHz only. For operation at clock rates higher than 100 MHz note the restrictions described in the data sheet.

Operation

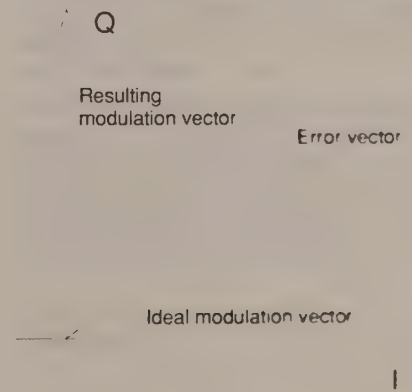
AMIQ has no local control elements and is remote-controlled via the serial interface or the IEC/IEEE bus. The output memory is also loaded via these interfaces. In addition, loaded waveforms can be temporarily stored on an internal hard disk and called up for the next output. Waveforms can also be loaded into AMIQ via the built-in disk drive

Stress Signals for I/Q Signals

The error vector of vector-modulated RF signals mainly depends on the characteristics of the I/Q modulator and modulation generator. The following characteristics are essential for a small error vector:

Amplitude imbalance

Differences in amplitude between the I and Q channels lead to an offset in the constellation diagram and thus to a narrower eye width for the modulation. This can be illustrated by an I/Q vector diagram:



Phase coincidence Phase differences and delay differences between I and Q also yield an error vector depending on the coding content.

DC content DC offsets produce residual carriers in the generated RF signal.

Each of the above stress factors in amplitude or phase leads to an inaccurate display of the desired vector component and thus to an error vector.

Special Characteristics for Use of AMIQ as I/Q Modulation Source

Symmetrical design In the development of AMIQ particular care was taken to keep the error vector as low as possible. The I and Q signal paths in the AMIQ are of identical design and the clock signals for the D/A converters for the two channels come from the same source. The programmed I and Q values for the D/A converter are always read together from the memory.

Internal alignments The two AMIQ channels can be aligned for optimum balance with the aid of the built-in amplitude and phase meter without any external equipment being required.

Internal fine tuning To compensate for possible amplitude and offset errors of the connected RF generator, amplitude and offset of the two channels can be fine tuned.

Delay correction Small delay errors between the channels, as may be caused for instance by not completely identical cables between AMIQ and I/Q generator, can be compensated for in the AMIQ in a range from -1 ns to +1 ns with a resolution of 10 ps.

External triggering The output can be started and stopped with an external trigger signal.

Marker outputs Four user-programmable and sample-accurately set marker outputs can be used, for instance, to drive external power ramping components.

Basic Operating Modes

AMIQ has two different clock rate modes and two amplitude modes which should be selected as required for the desired clock rate and waveform:

Clock rate mode 1 SLOW

This mode is automatically set if a clock rate **below 2 MHz** is selected on AMIQ.

The advantage offered by this mode is in the variation of the stored waveform length. In the case of AMIQ model 03, the waveform length can be varied from **24** to 4,000,000, in the case of AMIQ model 04 from 24 to 16,000,000 **in steps of 1**.

For clock rates between 2 MHz and 4 MHz, both the SLOW and the FAST mode can be selected. The SLOW clock rate mode can be selected with the command `CLOCK <frequency>,SLOW`

Clock rate mode 2 FAST

This mode is automatically set if a clock rate **above 4 MHz** is selected on AMIQ.

Please note that with this mode the waveform length can be varied **only in steps of 4,** i.e. in AMIQ model 03 from **24** to 4,000,000 and in AMIQ model 04 from 24 to 16,000,000. This means that the number of samples must be divisible by 4.

For clock rates between 2 MHz and 4 MHz, both the SLOW and the FAST mode can be selected. The FAST clock rate mode can be selected with the command `CLOCK <frequency>,FAST`

Amplitude mode Fix

This mode is characterized by a maximum performance of the output signal and should preferably be used for generating vector-modulated signals.

In the *Fix* mode, the level *cannot* be varied after D/A conversion, the amplitude of the output signal is determined only by the programming of the waveform D/A converter. When fully driven, the D/A converter yields an output amplitude of 0.5 V at the 50 Ω termination and thus corresponds to the maximum vector amplitude of the I/Q inputs of standard RF generators.

For accurate matching to the modulation inputs of the connected RF generator, the amplitudes of the I and Q outputs of AMIQ can be separately adjusted for full-scale operation. The zero offset of the outputs can also be optimally adapted to the RF synthesizer by slight variations.

Amplitude mode VAR

This mode is intended for all applications for which the I/Q inputs of the RF generator or the module to be tested require I/Q input levels which cannot be set with the amplitude mode *Fix*.

In the *VAR* mode the amplitude of the I/Q outputs can be *set* without the need to reprogram the respective waveform in the memory. The amplitude setting range is in this case twice as wide as in the *Fix* mode. In this mode also an analog inversion of the I and Q channels is possible. Because of the wide dynamic range for variable level tuning (20 dB), a poorer S/N ratio of the output signals may have to be accepted in this mode.

Signal Outputs

Marker Outputs

Control

AMIQ is provided with four rear marker outputs, two for the I channel and two for the Q channel (see "Rear View" in chapter 1). These outputs are controlled by the waveform memory with a 16-bit word width for I and Q. In this case the two least-significant bits (LSBs) in the waveform memory are set for the I and Q channels. Bit assignment for the four marker outputs:

Marker 1	LSB (bit 0) of I channel
Marker 2	Bit 1 of I channel
Marker 3	LSB (bit 0) of Q channel
Marker 4	Bit 1 of Q channel

When a waveform is loaded the markers are automatically programmed (see also "MARKer - Marker Management" in chapter 6).

Uses

Marker outputs are typically used for controlling the power ramping of I/Q modulators to increase the switch-off dynamic range.

Power ramping

With power ramping the pulse modulator input of the RF generator is used to switch off the RF signal synchronously with an I/Q symbol. Because of the delay difference between the I Q inputs and the pulse modulator input of the RF generator, the marker signal in the I/Q data stream applied to the pulse modulator input has to be shifted.

To ensure symbol-accurate power ramping, the marker outputs of AMIQ can be shifted with the remote-control command `:MARKer<n>[:LIST]` irrespective of the programmed waveform (see "MARKer – Marker Management" in chapter 6). The changed marker settings can then be stored together with the waveform.

Trigger generator

The marker outputs may of course also be used separately, eg to use AMIQ as a universal trigger generator

Connector

To obtain clear pulse shapes at the outputs, terminated lines should be connected to the marker outputs (50 Ω). The typical pulse amplitude at the termination is 2 V. This allows TTL inputs to be directly driven.

Change of I/Q outputs to the rear

Changing the I/Q outputs is possible only if option Differential Outputs (AMIQ-B2) is not fitted.

If the I and Q inputs of AMIQ are changed to the rear for rackmounting (AMIQB19), only the marker outputs 1 and 2 are available for markers. Marker outputs 3 and 4 are then used as Q and I outputs.

Clock Output and Input

Use of clock output

At the AMIQ clock output, a squarewave signal is present whose frequency corresponds to the clock rate selected on AMIQ. By means of this output, AMIQ can be used as a clock generator for synchronization.

The frequency can be set with high resolution (typ. 32 bits) between 10 Hz and 105 MHz. The frequency of 10 Hz, too, can be set with this resolution.

Note: *To be able to activate this output, AMIQ must not be in the STOP state.*

Connection of clock output

The clock output should be terminated with 50 Ω. For the level, the same conditions apply as for the marker outputs. A double shielded cable has to be used because of the steep edges and the high harmonics content of the clock signal.

Use of clock input

External clock input is meaningful for AMIQ models 03 and 04 when operated in conjunction with option AMIQ-B3 (Digital I/Q Output).
It enables two operating modes:

- Integration of AMIQ into a system with a system clock
- Feeding a DUT (e.g. D/A converter) with a spectrally pure external clock signal while maintaining clock/data synchronism

For detailed information on external clock input see "External Clock" section in this chapter.

Triggering

The output of a waveform on AMIQ can be started either by remote control (see chapter 6, "ARM/TRIGger/ABORt – Triggering, Sequence Control") or by an external trigger signal. The trigger input is a TTL input and its edge or active level can be selected. There are the following modes:

CONTinuous After the trigger is received, waveform output starts with the first point of the waveform and is repeated continuously. At the end of the waveform, output is continued immediately with the first point.

SINGle After the trigger is received, waveform output starts with the first point of the waveform and ends with the last point. Then the I/Q outputs go to idle state.

GATed After the trigger is received, waveform output starts with the first point of the waveform and is repeated continuously. After the end of the trigger event, waveform output is stopped and the I/Q outputs go to idle state. On the next trigger, waveform output starts with the first point of the waveform.

OFF No triggering; no data are output. Any ongoing waveform output is stopped and the I/Q outputs go to idle state.

- The following applies to all trigger modes:
- Before triggering and after the end of a trigger event, the I/Q outputs go to idle state (see chapter 6 "Waveform File Format" IDLE SIGNAL tag).
- The time between the reception of a trigger signal and the start of waveform output is as follows:

• Clock rate mode 1 (SLOW)	• Mode 1: 220 ns +(1 sample + 20 ns) jitter
• Clock rate mode 2 (FAST)	• Mode 2: 11 samples + 1 sample jitter

- The required pulse width for a reliable identification of the trigger signal is:

• Clock rate mode 1 (SLOW)	• min. 200 ns + 1 sample
• Clock rate mode 2 (FAST)	• min. 11 samples

- 1 sample is the time elapsed between two subsequent output values.

! For detailed information on the various trigger modes and examples of application see chapter 6, command :TRIGger:MODE OFF | GATed | SINGle | CONTinuous

I/Q Signal Adjustments

In the AMIQ, level, offset and delay difference of I/Q outputs can be adjusted. The respective commands are contained in the :CORR (command) subsystem (see "SOURce – Hardware Settings " in chapter 6). These adjustments affect the positions marked in the block diagram below (Fig.4-1).

Adjusting the Level

In the *Fix* amplitude mode, the output level can be adjusted by approx. +/-10% with the aid of the following commands. Possible external gain differences can thus be compensated for.

Command (example):
```
:CORR:GAIN:I:FIX -0.1
:CORR:GAIN:Q:FIX 0.1
```

Permissible range: –1.0 to +1.0

- The automatic internal adjustment of the AMIQ is performed via the `:CAL:AMPL?` query.
- In the *FIX* mode, the range –1 to +1 corresponds to an offset variation of approx. ±30 mV into 50 Ω.
- In the *VAR* mode, the range –1 to +1 corresponds to an offset variation of approx. ±75 mV into 50 Ω.

Adjusting the Offset

The DC offset of the output levels can be fine-tuned in a range of approx. 30 mV using the following commands. The voltage is specified in V (terminated into 50 Ω).

Command (example):
```
:CORR:OFFS:I:FIX 0.3
:CORR:OFFS:Q:FIX -0.2
```
or
```
:CORR:OFFS:Q:VAR -0.2
```

Permissible range: –1.0 to +1.0

- The automatic internal adjustment in the AMIQ is performed via the `:CAL:OFFS?` query.

Adjusting the Delay

For compensating slight differences in signal delay (caused eg by not completely identical cables or amplifiers), the I and Q output signals can be shifted against each other. The shift range is approx. ±1 ns at 10 ps resolution. The entry of positive values delays the I signal as against the Q signal.

Command (example):
```
:CORR:SKEW: -0.1
```

Permissible range: –1.0 to +1.0

AMIQ – Block Diagram

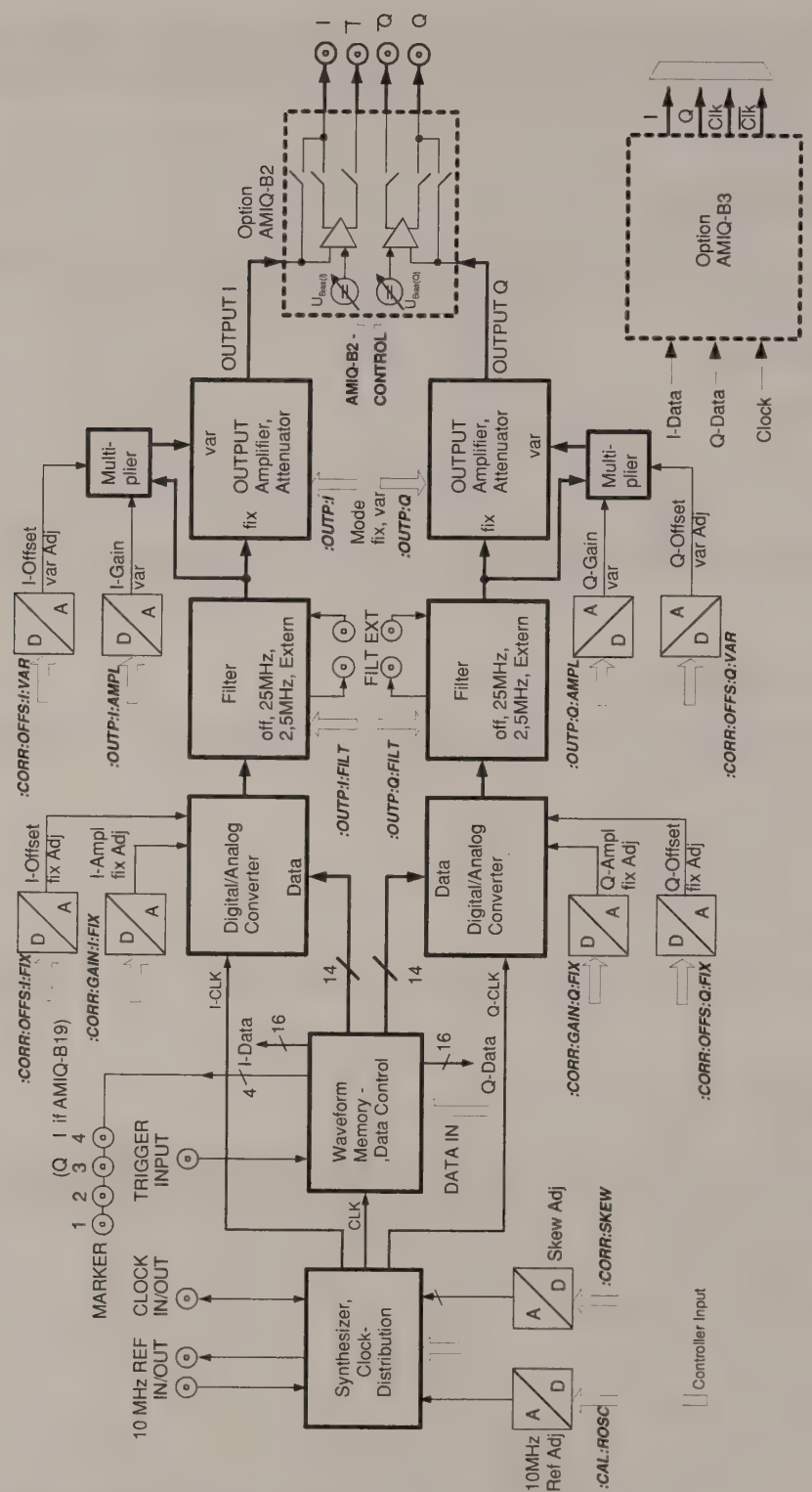


Fig. 4-1 Simplified block diagram of AMIQ

Measurement of Bit Error Rate

Option AMIQ-B1 allows the signal decoded by the DUT to be assessed. To do so the waveform memory is filled with a PRBS-modulated (pseudo random binary sequence) data sequence. The data are decoded by the DUT and forwarded to the AMIQ as clock and data signals. AMIQ synchronizes to the known PRBS sequence and counts the bit errors.

The BER measurement can also be performed separately (with data from another source).

Connector

The clock and data signals supplied by the DUT must have TTL level and are applied to the bit error rate input, a 9-contact SUB-D connector at the instrument rear labelled BER. The pin assignment is as follows:

	SUB-D connector	Adapter cord Part number 1110.3551.00
1,2,3,4,5	Ground	Shield
6	Bit clock input	"CLOCK"
7	Data input	"DATA"
8	DAT ENABle input	"DAT ENAB"
9	Restart	"RES"

The polarity of the clock and data signals, the PRBS polynomial and the integration time can be set with the respective remote-control commands. The input signals are not terminated in the AMIQ but applied to ICs type 74LVT14 via a 220 Ω resistor.

Signal Path and Waveform

Test setup

The desired signal is calculated with the aid of WinIQSIM and loaded into AMIQ. It is applied to an RF modulator via the I/Q outputs and forwarded to the DUT (device under test). The latter demodulates the received source bits and returns them to AMIQ together with a transfer clock. In the AMIQ, the data bits are checked for errors. The total of the transmitted bits and the faulty bits are counted. The quotient of error bits/total bits is the BER.

PRBS data

To be able to detect faulty bits in a BER measurement, the algorithm used for data generation must be known. Data are calculated with the aid of so-called pseudo-random binary sequences (PRBS). These are quasi-random bit sequences which are repeated according to the selected polynomial.

An advantage of the PRBS data is that the bit error detector has only to know the calculation algorithm but not the total sequence. Furthermore, the analysis can be started anywhere in the bit stream, ie the bit-stream source and the analyzer need not be synchronized.

To get familiar with the BER measurement and to check the BER measurement function in a simple way, a waveform file named PRBS9_E.WV is stored in the AMIQ waveform directory. This file contains a PRBS sequence with an error bit, which should produce an error indication of about 0.19% in WinIQSIM. The COMMENT tag of this waveform includes a short description allowing a fast check of the BER measurement function.

{COMMENT: This is a waveform for checking the BER measurement. The waveform is applied to two marker outputs on the rear panel (no signal at I/Q output). To check the BER measurement, connect the adapter cord (Order No. 1110.3551.00) to the rear BER connector and the DATA cable to MARK1 and the CLOCK cable to MARK2. The signal at MARK1 (DATA) is a PRBS sequence with one error bit. To check the BER measurement with WinIQSIM, select 'Remote Control and Bert', 'Load HD File' and PRBS9_E, tick on Marker Ch.1 and Ch.2, select 'BERT' and start the BER measurement with 'Cont'. A bit error rate of approximately 0.19% should appear.}

Transfer clock

If the DUT does not provide a transfer clock, a marker channel can be programmed instead as a clock output.

This is explained in the operating manual for WinIQSIM, chapter "Data Editor", and in the application manual "Software WinIQSIM for Calculating I/Q Signals for Modulation Generator AMIQ", chapter 5 "BER measurement with WinIQSIM and AMIQ", order no. 1027.3007.30.

Test Method

Generation of PRBS data

PRBS data are generated with the aid of a feedback shift register. The feedback points are determined by the calculation algorithm. An initial state selected at random yields exactly one subsequent state. The initial state and therefore the subsequent state occur only once in the whole data sequence.

Feedback of data stream

If the feedback shift register is filled with a data sequence at the beginning of a measurement and the register is then switched from "filling" to "feedback", the register will generate a data sequence which is exactly identical to the one it should receive from the DUT. Faulty bits can thus be identified and counted by comparing the received data to the results obtained from the shift register.

This method has the advantage that the analysis can be separated from signal generation (logically and with respect to time). Consequently, delays caused by the DUT, the use of other PRBS sources and transmission over long distances with spatially separated transmitter and receiver, do not cause any problems.

Faulty bits in output status

If a bit error is already present in the output state (faulty bits are not detected during "filling"), the shift register starts from an incorrect position in the whole data string. As a result all subsequent states will be faulty. Since, statistically, every second bit is faulty, the BER will be about 50%. In this case a new measurement is started automatically so that the error goes unnoticed by the user.

BER measurement with uninterrupted repetition of the random sequence

The non-integrating BER measurement operates with random sequences which are stored in the AMIQ memory cyclically. The length of the random sequence is obtained from 2 to the degree of the polynomial less 1, ie PRBS9 has a length of 511 (2^9 is 512, less 1).

The BER measurement can be set with the command `BERT:SETup:RESTart INTernal` and output on the CLOCK and DATA line.

The analysis data are interrupted by other data

The data bits carry "extraneous" data such as sync, preambles, other channels etc in addition to the PRBS data To identify the data to be evaluated, the BER measurement must be provided with a validity signal (DAT ENABle input) apart from the actual data. This DAT ENABle signal is generated either by the DUT or provided by the AMIQ as a marker channel.

The DAT ENABle signal can be defined in the data editor when the data are generated in the WinIQSIM It may be necessary to match the timing of the marker signal to the data of the DUT (see below).

The BER measurement using the AMIQ should be set to the use of a validity signal (DAT ENABle); for this the polarity in menu `AMIQ -> Remote Control` and `BERT` is set. The setting DAT ENABle = high signifies that data from the DUT are counted and subjected to a BER measurement only if the DAT ENABle input is at 1.

BER measurement with interrupted random sequence – integrating BER measurement

Depending on the type of data, oversampling and the finite memory length of AMIQ, it may happen that the generated random sequence is not cyclically repeated at the memory wrap-around but that a break occurs at this point. In an ordinary BER measurement which relies exclusively on the CLOCK and DATA signals, this break would cause a loss of synchronization and thus about 50% of faulty bits.

A random sequence with a discontinuity can be handled with **the integrating BER measurement** and is switched on by means of the `BERT:SETup:RESTart EXTern` command. The BER measurement must be halted in time and re-started at the beginning of the data sequence. Halt and start is effected using a signal at the RES input (pin 9 of D-sub connector): A logic 1 at this input resets the BER measurement, a 0 starts the measurement. It is useful to link this input with a marker channel of the AMIQ in which a single 1 (about 2 bits long) is coded at the beginning of the data sequence. The marker channel then starts the BER measurement anew for each memory cycle (of the discontinuity).

If the data signals are interrupted from other data (eg preambles), the latter can result in bit errors. The BER measurement can be interrupted for such data with the aid of the DAT ENABle input on a different marker channel.

In the integrating BER measurement the individual measurements are added up under the control of a signal at the RES INPUT until the predefined total number of data or errors bits are attained or exceeded.

Complex measurement and signal sequences of this type cannot be easily generated manually so with the use of the Windows software WinIQSIM from R&S it is possible generate data sequences for the BER measurement. It can thus be ensured that the DAT ENAB and RES signals are timed correctly for the data signals and discontinuity.

See also chapter titled "Data Editor" in the WinQSIM manual as well as application manual "Software WinIQSIM for Calculating I/Q Signals for Modulation Generator AMIQ", chapter 5 "BER measurement with WinIQSIM and AMIQ" Order No. 1027.3007.30.

Note: *The flexible programming of the test hardware permits other BER measurement methods to be used, eg comparison with output pattern, masking certain time and data ranges. Contact your local R&S sales office for further information.*

PRBS Polynomials

A feedback shift register is used for generating and checking the PRBS. The feedback is switched depending on the polynomial used. The sequence length of a generator is $2^n - 1$, n being the degree of the polynomial.

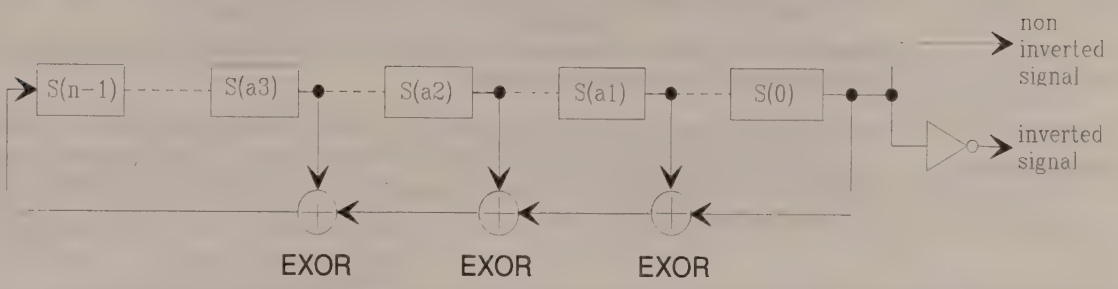


Fig. 4-2 PRBS Polynomials

PN generator	n	a1	a2	a3	Output	Applicable standard
PN9	9	4	-	-	non-inverted	ITU-T Rec. O.153 Fascicle IV.4
PN11	11	2	-	-	non-inverted	ITU-T Rec. O.152 Fascicle IV.4
PN15	15	1	-	-	inverted	ITU-T Rec. O.151 Fascicle IV.4
PN16	16	5	3	2	non-inverted	--
PN20	20	3	-	-	non-inverted	ITU-T Rec. O.153 Fascicle IV.4
PN21	21	2	-	-	non-inverted	--
PN23	23	5	-	-	inverted	ITU-T Rec. O.151 Fascicle IV.4

Measurement Result, Accuracy, Measurement Time

Value range: The measured BER (ie ratio of faulty bits to total bits) is normally between 10^{-2} and 10^{-9}. This means that a great number of bits may have to be checked before a faulty bit is detected. Because of the great number of bits involved the measurement time is usually very long.

Since 32-bit-wide counters are used for the total bits and the error bits, the maximum measurement time is $4.29 \cdot 10^9$ bits.

Statistics The BER measurement measures statistical bit errors, ie errors which do not occur at regular intervals but at random. Although a single measurement determines the exact number of errors in the measured range, a reliable BER rate can only be obtained when a sufficient number of errors occurs in the observed range with the result that the single BER measurement result approaches the true error rate with high probability .

End criteria To keep the measurement time short with low and high bit error rates, two end criteria have been defined in AMIQ for the BER measurement.

- Criterion 1: Total number of bits

  The measurement is terminated when the total of the specified bits is reached. Due to this criterion the BER measurement is reliably stopped after the specified number of bits even if no error or only a few errors were detected and the measurement result is not very accurate (few bit errors).

- Criterion 2: Number of faulty bits

  The measurement is terminated when the specified number of bit errors is detected. With this criterion, the measurement is rapidly terminated when high bit error rates occur. Since a great number of errors is counted, the measurement is relatively accurate.

The two criteria are used together. The criterion which finally yields a valid result is indicated by AMIQ after a result query.

Interruption of measurement

At the end of a measurement, the restart of a new one is delayed until the first measurement result has been queried with `BERT:RES?`. The resulting brief measurement interruption is irrelevant because the subsequent measurement will be synchronized within 24 data bits.

Possible Problems with BER Measurement and Related Solutions

Fault	Possible cause	Fault description/remedy
BER measurement does not synchronize	No signals from DUT received or the signal level is not correct.	➢ Read the activity of the inputs used for the BER measurement on the WinIQSIM or SMIQ display. A green lamp (on the screen) next to the name (clock, data) indicates that the respective line is active.
	BER measurement using PRBS sequences was not activated in AMIQ.	➢ Activate the BER measurement using PRBS sequences once before the measurement is started. This is done with command `BERT:SEL "PRBS"`. This command ensures that the measurement hardware is loaded with the correct configuration file. Then switch AMIQ off and on again to load the configuration file to the measurement hardware.
	The selected PRBS is not correct.	Normally, the PRBS of the data is transmitted together with the waveform file and used as a default setting. If the PRBS is changed, the BER measurement cannot synchronize to the data (because the calculation polynomial is not correct).
	A wrong clock edge is used for triggering violating setup or hold times.	➢ Check the bit clock signal, the data signal and the DAT ENABle signal, if any, on an oscilloscope. The fault may also be caused by reflections on the clock line, which switch the data signal twice into the BER measurement; see section *Avoid Reflections in the BER Measurement* on page 4.17.
	Incorrect polarity of data signal (or DAT ENABle signal).	In this case the PRBS cannot synchronize either. Note that an inversion of the output signal specified for some cases by the PRBS standard is performed automatically upon PRBS selection. Manual inversion of the data signal is thus not required.
	A bit error occurs during synchronization (eg the synchronization time is nine data bits with PRBS9)	The BER measurement is started at a wrong position so that about 50% of the subsequent data bits are identified as faulty. This "incorrect" result is rejected by the AMIQ software and the measurement is automatically repeated (upon the next query by WinIQSIM or SMIQ).

Fault	Possible cause	Fault description/remedy
No clock received from DUT	When testing RF components, the clock recovery may no be available. An external clock is however required for clocking the data during the BER measurement	An AMIQ marker channel can be used instead of the clock from the clock recovery circuit. To do so proceed as follows: ➢ Connect the marker channel (eg marker 1) to the clock input (pin 7) of the BER measurement. ➢ Program a 0-1 transition in this marker channel for each data bit to be evaluated. This method cannot be used with modulations using a value >1 (eg QPSK) as several bits are coded per symbol. It may be possible to select a bit pattern in the marker channel which permits a clock edge to be generated for each bit in the symbol. In this case a sufficiently high oversampling value must be selected. BERT is selected by WinIQSIM in the data editor for the generation of a suitable marker signal. For details refer to the WinIQSIM manual.
Measured BER too high	The data are switched with the wrong clock edge and/or the eye pattern of the data is not optimally met.	➢ Check the clock/data relationship by means of an oscilloscope and set optimum timing. ➢ If the clock is derived from an AMIQ marker channel, shift the channel by a few sampling points (see `OUTPUT:MARKER<n>:DELAY`).
	BER measurement [FW1]does not synchronize .	If data that are not cyclically repeated (ie when an interruption occurs at the memory wrap-around), the measurement will identify about 50% of the bits as faulty after the wrap-around. ➢ Make sure that the measurement is optimally started at the beginning of the sequence via the signal on the REStart line (see "BER measurement with interrupted random sequence – integrating BER measurement" in section "Test Method" on page 4.11).

Further Hints and Tricks

Correction of DUT delay

- If all signals come from the DUT, the delay of the DUT will not cause any problems. In this case the BER measurement is performed completely independent of the AMIQ signal output. After the start of the measurement, the BER is automatically synchronized to the applied data
- If the clock, DAT ENABle or restart signals are not supplied by the DUT but generated on the AMIQ marker outputs and the signals are used together with the clock or data from the DUT, delays may occur which have to be corrected.

The DUT will normally require a certain time to return the data bits to AMIQ. This delay may be less than one bit. The signal on the marker channel is directly applied from the output socket to the input for the BER measurement and is therefore not delayed. The signals on the marker channels (eg the clock signal) must therefore be shifted with reference to the I/Q output data so that they are optimally time-synchronized.

This can be done in two ways

➢ Shift the marker of a loaded trace by a specified number of samples using the function `OUTPUT:MAR...:DELAY <samples>`.

➢ A pattern is used for generating the clock signals, which defines the sequence of 010 transitions in the marker channel. Modify this clock pattern to shift the active clock edge (referred to the I Q output).

Then:

➢ Check the timing of the BER signals on an oscilloscope.

➢ Connect the marker channel containing a clock signal to the clock input (pin 7) of the BER IC.

Installation of Option AMIQ-B1, BER Measurement

If the instrument is ordered with option AMIQ-B1, the option comes as active and ready for operation. If the option is subsequently ordered, proceed according to the instructions supplied with the option. If these instructions are not available, follow the instructions given below:

- Connect AMIQ to a controller.
- Activate option AMIQ-B1 in the AMIQ. To do so send command **`SYST:OPT AMIQB1,xxxxxxxx`** to AMIQ, **`xxxxxxxx`** being the key number.

The key number is supplied together with the option. The option needs not be reactivated after a firmware update.

The activation command can be sent to AMIQ under *Remote Control and BERT -> Test and Adjustment -> Send Command to AMIQ* in the *AMIQ* menu of WinIQSIM.

- To activate the BER measurement using PRBS sequences, activate this measurement mode with command **`BERT:SEL "PRBS"`**.

This prepares the loading of the measurement hardware with the correct configuration file. AMIQ has to be switched off and on again to load the configuration file to the measurement hardware when the measurement is started. This selection command has to be sent only once. Once the configuration has been set, it is preserved even after a firmware update.

Activation is checked when a BER measurement is called in WinIQSIM and carried out automatically if not done before.

Avoid Reflections in the BER Measurement

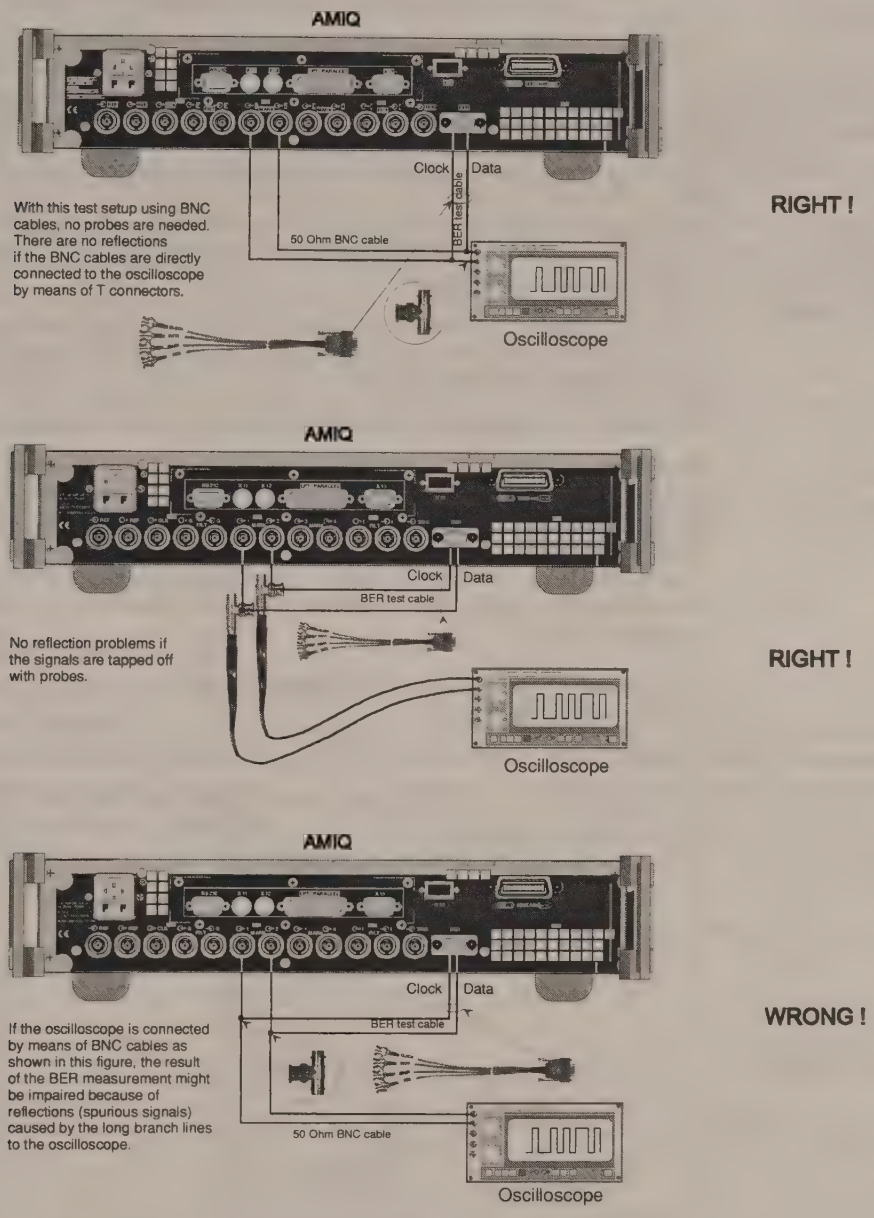

AMIQ
Clock
Data
BER test cable
50 Ohm BNC cable
With this test setup using BNC cables, no probes are needed. There are no reflections if the BNC cables are directly connected to the oscilloscope by means of T connectors.
Oscilloscope
RIGHT !
AMIQ
Clock
Data
BER test cable
No reflection problems if the signals are tapped off with probes.
Oscilloscope
RIGHT !
AMIQ
Clock
Data
BER test cable
If the oscilloscope is connected by means of BNC cables as shown in this figure, the result of the BER measurement might be impaired because of reflections (spurious signals) caused by the long branch lines to the oscilloscope.
50 Ohm BNC cable
Oscilloscope
WRONG !
New BER test cable are labelled DAT ENAB instead of MASK
CLOCK
DATA
MASK
RES
The BER test cable is part of the option AMIQ-B1. It can be ordered as a replacement part with the stock no. 1110.3551.00. The pin assignment is described in section "Connector" in this chapter.

Fig. 4-3 Avoid reflections in the BER measurement

Application Example for Option Differential Outputs (AMIQ-B2)

Option Differential Outputs (AMIQ-B2, stock no. 1110.3700.02) is a hardware option ready for operation immediately after being fitted by an R&S service technician. Essentially, a PC board must be installed and the front panel of AMIQ must be replaced by another one containing 4 output connectors.

Control of the differential outputs by WinIQSIM is supported starting with version 2.10 of both products.

Advantages of differential outputs compared to asymmetric outputs

Manufacturers equip IQ modulator components with differential inputs mainly to obtain improved technical data concerning port insulation, spurious responses and harmonics.

Option AMIQ-B2, Differential Outputs, allows to feed these components correctly with symmetric signals in order to make full use of the technical specifications of the modulator ICs.

An operating voltage of +5 V, recently also +3,3 V, referred to ground is used.

As a consequence of this asymmetric power supply, the DC level (= operating point of the corresponding input) must be set to the center of the operating voltage range by means of an external electric network. The additional expense to install the external electric network is saved by option AMIQ-B2. This option allows to superimpose a DC voltage ranging from –2.5 V to + 2.5 V (called bias voltage in the following) upon the symmetric I or Q signal (high-impedance input).

Example

The following application example shows the function of the option combined with the AMIQ basic unit.

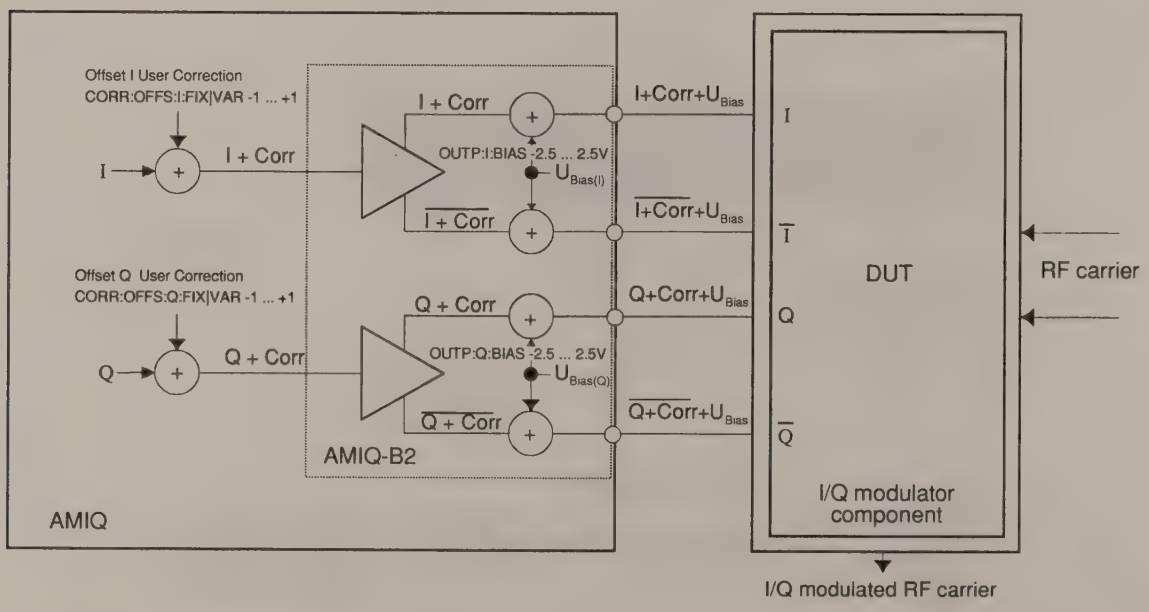


Fig. 4-4 Application block diagram of option AMIQ-B2

Functions of the structure shown above:

- AMIQ provides the modulation signals I and Q (asymmetric).
- Option AMIQ-B2 outputs these signals together with the inverted signals $\overline{I}$ and $\overline{Q}$. The signals control the modulator chip.
- To set the operating point of the modulator component (DUT) a DC voltage U_{Bias} that can be adjusted individually for I ($\overline{I}$) and Q ($\overline{Q}$) is superimposed upon the modulation signals.
- To optimize the RF carrier suppression an additional correction voltage (Corr), again individually adjustable for both channels I and Q, can be superimposed upon the initial signals. Inclusion of option AMIQ-B2 causes the correction voltages to be set in positive direction at the non-inverting outputs, in negative direction at the inverting outputs. This doubles the absolute value of the correction between I and $\overline{I}$ or between Q and $\overline{Q}$. Should it be necessary, a difference between the best operating points for I and Q of the modulator chip can be balanced.

The bias voltage of the option represents basically a „common mode" voltage for the four signal outputs while the offset voltage selected via „user correction" in the AMIQ basic unit represents a balance setting between the inverting and the non-inverting output.

Once the operating point of the DUT is set via U_{bias} it can be simply preserved by selecting an output impedance of 50 Ω for the OFF state even if the signal level is switched off. If „High Impedance" is selected, the bias voltage will be set to zero whenever the output is switched off.

AMIQ Model 03 / 04

AMIQ models 03 and 04 can be fitted with the option AMIQ-B3 (digital I/Q output) and supplied with an external clock, see also "Option AMIQ-B3 (digital I/Q output)" and "External Clock" in this chapter.

AMIQ model 04 is provided with a much larger memory and can thus store traces up to 16 000 000 I/Q values. Compared with model 03 (4 000 000 I/Q values) model 04 has four times greater memory capacity. Apart from that there is no difference between the two models.

Digital I/Q Output Option AMIQ-B3

The digital I/Q output option is available for models 03 and 04 and supplies the 16-bit data bus for both channels I and Q at a 68-pin front-panel connector on the AMIQ basic unit. Of the 16 bits the two least significant bits (d0 and d1) are used as marker signals and the remaining 14 bits for signal generation. This data bus also drives the two internal 14-bit main DACs. The associated bit clock is supplied in addition.

Using version 3.10 and higher of the program WinIQSIM the digital output can be activated (ON) or deactivated (OFF) as long as pin 66 at the connector is high (see pin allocation). If this pin is low, then the outputs are permanently of high-impedance. This avoids latch-up effects of the following circuit in the absence of supply voltage.

Traces calculated with versions < 3.10 of WinIQSIM had previously a width of 14 bits, ie d0 and d1 were fixed at 0 and d2 was rounded by means of d1. Data bits d0 and d1 could be used as marker bits.

Each trace generated by WinIQSIM version 3.10 and higher has a resolution of 14 or 16 bits, depending on the selected output resolution (see "Operation"):

- For an output resolution of 8 to 14 bits WinIQSIM generates traces with a generation resolution of 14 bits.
- For an output resolution of 15 or 16 bits WinIQSIM generates traces with a generation resolution of 16 bits.

Example:

A 12 bit output resolution is set in WinIQSIM. WinIQSIM calculates and transfers the IQ data with a resolution of 14 bits (so the marker signals remain accessible). In the {RESOLUTION: x,y} tag, the trace contains the generation resolution (14 bits) as well as the output resolution (12 bits). When this trace is loaded into the output RAM of the AMIQ, it is automatically quantized to 12 bits. Still it is possible to increase the output resolution of the trace to a maximum of 14 bits later without calculating the trace again.

Each trace generated by WinIQSIN version 3.10 or higher has a resolution of 14 or 16 bits. From this version up each trace contains the new {RESOLUTION: x,y} tag with

- 'x' = generation resolution (bit width of trace generated by WinIQSIM) and
- 'y' = output resolution (bit width of trace output by AMIQ).

Traces with a generation resolution of 14 bits allow the use of markers without any restriction. However no markers are available with traces of 16-bit generation resolution because data bits d0 and d1 represent the least significant bits of the I/Q values.

When markers are active and a trace with a generation resolution of 16 bits is loaded, the markers are switched off and marker commands are rejected. Decreasing the output resolution with the command `OUTPut:RESolution 8...16` does not allow the use of markers since the reduction of the resolution is achieved mathematically with a rounding logarithm by setting data bits d0 and d1 to 0 which means that there can be no valid markers. Although loading marker list is theoretically possible after the reduction of the output resolution to ≤ 14 bits, no use was made of this for the sake of clarity of operation – the decisive factor for the execution of marker commands is solely the resolution of generation.

A generation resolution of 16 bits has no relevance for the I/Q outputs; in analog operation same as before d2 ... d15 go to the 14-bit converter. The higher resolution can be fully exploited only together with the digital I/Q option (AMIQ-B3) and permits a 12-dB higher resolution than at the analog output.

The output resolution of a trace can subsequently be modified with the IEEE 488 command `OUTPut:RESolution 8...16 and` must always be ≤ the generation resolution.

The command `OUTPut:RESolution 8...16` can be used independently of the digital I/Q output option (AMIQ-B3) and can be quite useful to reduce the output resolution of the analog outputs to observe the DUT's response.

Reducing the output resolution has the effect of setting unused bits to 0 and rounding the value. The value is always output MSB-justified at the digital I/Q output and at the 14-bit D/A converter.

To synchronize the digital data output via the digital I/Q output option (AMIQ-B3) with a system clock, AMIQ is to be driven with an external clock. To do this, the clock connector on the rear of the AMIQ basic unit is to be set from output to input in the WinIQSIM program (see section "External Clock" on page 4.24, "Operation").

To be able to work with a bit clock greater than 25 MHz to 30 MHz, it is recommended to plug the DUT directly to the 68-pin connector or, if possible, to use short connecting cables to avoid interfering reflections. In such cases, data and clock lines should be terminated with resistances of 120 Ω to 150 Ω.

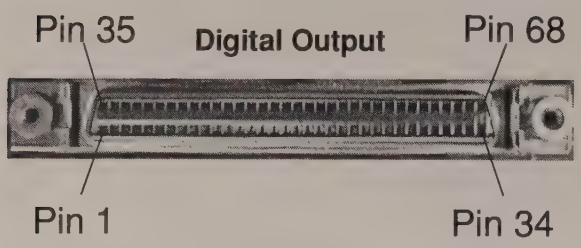
Operation of Digital I/Q Output Option (AMIQ-B3) using WinIQSIM

Modulation Generator AMIQ is operated via the WinIQSIM program (versions required: WinIQSIM = 3.10).

The analog and digital outputs can be activated independently from one another. The AMIQ can be set in the following way:

- Click the REM button in the top bar or open the menu item "AMIQ" and "Remote Control and BERT...". The AMIQ operator window now appears.
- The digital I/Q output can be activated or deactivated following the selection of the "Hardware-Setting" submenu under "Digital Output".

Pin Allocation of Digital I/Q Outputs



The output pins of the option has the following features:

Pin 66: the wiring of this pin (PWR_SENSE) enables or disables the outputs:
Low (<0.8 V) = outputs disabled, of high impedance
High (>2.4 V) = outputs enabled

Pin 67: a supply voltage (+3.3 V or +5 V) is provided for an external circuit. The magnitude of V_{CC} depends on the wiring at Pin 68.

Pin 68: the wiring of this pin determines the supply voltage level at pin 67.
Low (<0.8 V) = +5 V
High (>2.4 V) = +3.3 V
The high level of data, marker and clock signals adapts to the selected supply voltage level.

Further allocation of pins:

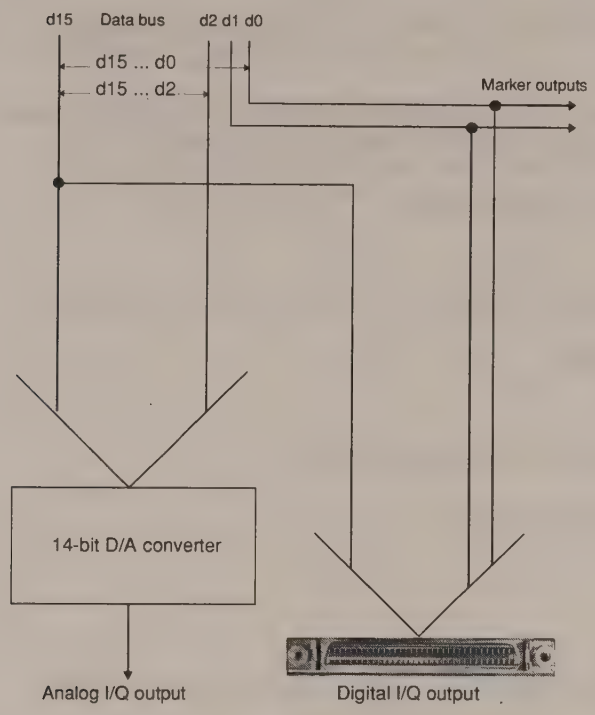
Pins 1 to 16:	data I0 to I15	(I0 ≡ marker 1, I1 ≡ marker 2)
Pins 17 to 32:	data Q0 to Q15	(Q0 ≡ marker 3, Q1 ≡ marker 4)
Pin 33:	bit clock	
Pin 34:	inverted bit clock	
Pins 35 to 65:	ground	

Brief Specifications

Table 4-1 Specifications of option AMIQ-B3

Output	68-contact connector (mini D-sub, half pitch)
Number of channels	2 (one each for I and Q)
Resolution	8 to 16 bits (selectable), no marker output for wordwidth 15 or 16
Max. clock frequency	100 MHz (at clock frequencies greater than 40 MHz, the 20 to 25 ns AMIQ delay between the input clock and the output data must be taken into account)
Output impedance	Approx. 30 to 50 Ω
Data output level	+3.3 or +4.0 V to +4.5 V (LVT or ABT high level)
V_{CC} level	+3.3 V or +5 V/0.3 A (selectable)
Clock output	Normal and inverted polarity

Technical Details



Channel I: d0 ≡ marker 1, d1 ≡ marker 2
Channel Q: d0 ≡ marker 3, d1 ≡ marker 4

IEEE 488 Commands

The following IEEE 488 commands apply to option AMIQ-B3:

Table 4-2 IEEE 488 commands for option AMIQ-B3

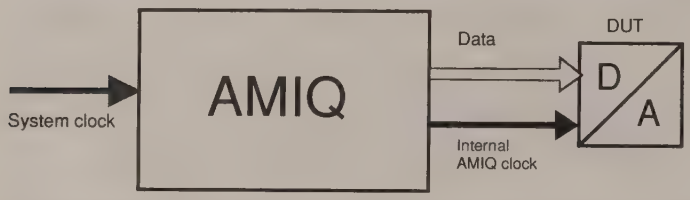
Section (see chapter 6)	IEEE 488 commands
OUTPut – hardware settings	OUTPut:DIGital ON|OFF OUTPut:RESolution 8 ... 16 OUTPut:MARKer<n> ON|OFF OUTPut:MARKer<n>:DELay <samples>
Common commands	*IDN? *OPT?
SYSTEM – different settings	SYSTem:OPTion?
DIAGnostic – hardware diagnosis	DIAG:ABO:ID?
Marker management	MARKer<n>[:LIST] <marker list>
Trace file format	Tag {RESOLUTION: x,y}

External Clock

Brief Description

AMIQ 03 and 04 can be fed with an external clock at the rear-panel connector CLK. Using an external clock together with option AMIQ-B3 (digital I/Q output) enables the following operating modes:

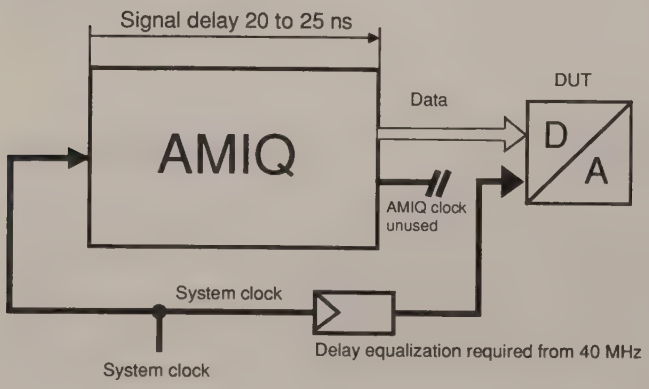
Integrating an AMIQ into a system with system clock



Advantage clock frequencies of up to 100 MHz, clock and data synchronous

Disadvantage clock may become noise through coupling in AMIQ

Feeding a DUT (eg D/A converter) with a spectrally clean external clock whilst retaining clock/data synchronization



Advantage clean clock for DUT

Disadvantage clock frequencies of only up to 40 MHz possible
clock frequencies of 40 to 100 MHz require delay equalization of the clock line to the DUT

Operation

Modulation Generator AMIQ is operated via the WinIQSIM program (versions required: WinIQSIM = 3.01BETA, AMIQ-FW = 3.0BETA).

- Click the REM button in the top bar or open menu item "AMIQ" and "Remote Control and BERT...". The AMIQ operator window now appears.
- The "Clock Mode" can be selected under "Source, Trigger ..." following the selection of the "Hardware Setting" submenu.

For IEC/IEEE-bus command and frequency ranges see chapter 6: `SCLock INTernal|EXTSlow|EXTFast`.

5 Remote Control - Basics

The instrument is equipped with an IEC bus interface according to standard IEC 625.1/IEEE 488.1 and a RS-232 interface. The connectors are located at the rear of the instrument and permit to connect a controller for remote control. The instrument supports the SCPI version 1996.0 (Standard Commands for Programmable Instruments). The SCPI standard is based on standard IEEE 488.2 and aims at the standardization of device-specific commands, error handling and the status registers (see section "SCPI Introduction").

This section assumes basic knowledge of IEC bus programming and operation of the controller. A description of the interface commands can be obtained from the relevant manuals.

The requirements of the SCPI standard placed on command syntax, error handling and configuration of the status registers are explained in detail in the respective sections. Tables provide a fast overview of the commands implemented in the instrument and the bit assignment in the status registers. The tables are supplemented by a comprehensive description of every command and the status registers. Detailed programming examples of the essential functions can be found in chapter 7, "Programming Examples". The examples for IEC bus programming are all written in QuickBASIC.

Note: *In contrast to instruments with manual control, which are designed for maximum possible operating convenience, the priority of remote control is the "predictability" of the device status. This means that when incompatible settings are attempted, the command is ignored and the device status remains unchanged, i.e. other settings are not automatically adapted. Therefore, IEC/IEEE-bus control programs should always define an initial device status (e.g. with the command *RST) and then implement the required settings.*

Short Introduction

Chapter 2, "Getting Started", outlines a short introduction to remote control of the AMIQ. The chapter also describes how the transfer parameters for RS-232 and the IEC bus can be set without using remote control commands.

Messages

The messages transferred via the data lines of the IEC bus and the serial interface (see section "Hardware Interfaces" in this chapter) can be divided into two groups:

- **interface messages**
- **device messages**

Interface Messages

Interface messages are transferred on the data lines of the IEC bus, the ATN control line being active. They are used for communication between controller and instrument and can only be sent by a computer which has the function of an IEC bus controller.

Interface commands can be further subdivided into

- **universal commands**
- **addressed commands**

Universal commands act on all devices connected to the IEC bus without previous addressing, addressed commands only act on devices previously addressed as listeners. The interface messages relevant to the instrument are listed in section "Hardware Interfaces" in this chapter, subsection "Interface Messages".

There are no interface message for the RS-232 interface. Only the "Device Clear" is emulated by the BREAK-signal of the serial interface (see section "Interface functions" on page 5.25). Other interface messages are replaced by device messages (e.g. "*GTL").

Device Messages (Commands and Device Responses)

Device messages are transferred via the data lines of the IEC bus (the "ATN" control line not being active) or via the serial interface. The ASCII code is used. The device messages are largely identical for the two interfaces. A distinction is made according to the direction in which device messages are transferred:

– **Commands** are messages the controller sends to the instrument. They operate the device functions and request information. The commands are subdivided according to two criteria:

1. According to the effect they have on the instrument:

   Setting commands cause instrument settings such as reset of the instrument or setting the output level to 1 Volt.

   Queries cause data to be provided for output on the IEC bus, e.g. for identification of the device.

2. According to their definition in standard IEEE 488.2:

   Common commands are exactly defined as to their function and notation in standard IEEE 488.2. They refer to functions such as management of the standardized status registers, reset and selftest.

   Device-spec. commands refer to functions depending on the features of the instrument such as frequency setting. A majority of these commands has also been standardized by the SCPI committee (cf. section "SCPI Introduction").

– **Device responses** are messages the instrument sends to the controller after a query. They can contain measurement results, instrument settings and information on the instrument status (cf. section "Responses to Queries").

Structure and syntax of the device messages are described below. The commands are listed and explained in detail in chapter 6.

Structure and Syntax of the Device Messages

SCPI Introduction

SCPI (Standard Commands for Programmable Instruments) describes a standard command set for programming instruments, irrespective of the type of instrument or manufacturer. The goal of the SCPI consortium is to standardize the device-specific commands to a large extent. For this purpose, a model was developed which defines the same functions inside a device or for different devices. Command systems were generated which are assigned to these functions. Thus it is possible to address the same functions with identical commands. The command systems are of a hierarchical structure. Fig. 5-1 illustrates this tree structure using a section of command system SYSTem, which allows to define various device settings. Most of the other examples concerning syntax and structure of the commands are taken from this command system.

SCPI is based on standard IEEE 488.2, i.e. it uses the same syntactic basic elements as well as the common commands defined in this standard. Part of the syntax of the device responses is defined with greater restrictions than in standard IEEE 488.2 (see section "Responses to Queries").

Structure of a Command

The commands consist of a so-called header and, in most cases, one or more parameters. Header and parameter are separated by a "white space" (ASCII code 0 to 9, 11 to 32 decimal, e.g. blank). The headers may consist of several key words. Queries are formed by directly appending a question mark to the header.

Note: *The commands used in the following examples may not in every case be implemented in the instrument.*

Common Commands

Common (=device-independent) commands consist of a header preceded by an asterisk "*" and eventually one or several parameters.

Examples:

`*RST`	RESET, resets the instrument.
`*ESE 253`	EVENT STATUS ENABLE, sets the bits of the event status enable registers.
`*ESR?`	EVENT STATUS QUERY, queries the contents of the event status register.

Device-specific commands

Hierarchy

Device-specific commands are of hierarchical structure (see Fig. 5-1). The different levels are represented by combined headers. Headers of the highest level (root level) have only one key word. This key word denotes a complete command system.

Example:

`:SYSTem` This key word denotes the command system `:SYSTem`.

For commands of lower levels, the complete path has to be specified, starting on the left with the highest level, the individual key words being separated by a colon ":".

Example:

```
:SYSTem:BEEPer:STATe ON
```

This command is located on the third level of the `SYSTem` system. It switches on the beeper (acoustic signal).

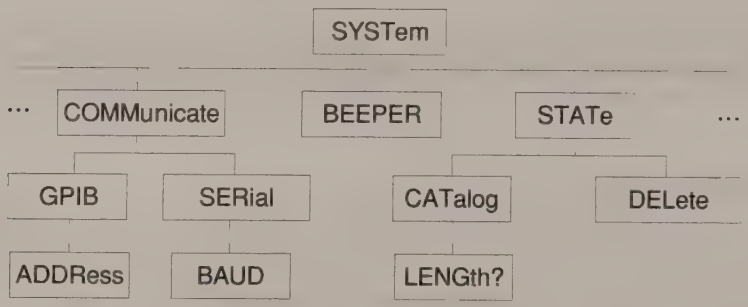


Fig. 5-1 Example for the tree structure of the SCPI command systems: The `SYSTem` system

Some key words occur on several levels within one command system. Their effect depends on the structure of the command, i. e. on the position in the command header they are inserted in.

Example: `:MMEMory:DATA:LENGth?`

This command contains the key word LENGth? in the third command level. The command returns the number of waveform files in the current directory.

```
:MMEMory:DCATalog:LENGth?
```

This command contains the key word LENGth? in the third command level. It returns the number of waveform directories below the virtual root directory.

Optional key words

Some command systems permit certain key words to be optionally inserted into the command header or omitted. These key words are marked by square brackets in this manual. The full command length must be recognized by the instrument for reasons of compatibility with the SCPI standard. Some commands are considerably shortened by omitting optional key words.

Example: `:MARKer<n>[:LIST] <marker_list>`

This command transfers a list of markers to the AMIQ. The following command has the same effect:

```
:MARK<n> <marker_list>
```

Note: *An optional key word must not be omitted if its effect is specified more precisely by a numeric suffix.*

Long and short form

The key words feature a long form and a short form. Either the short form or the long form can be entered, other abbreviations are not permissible.

Example:
```
:STATus:QUEStionable:ENABle 1
:STAT:QUES:ENAB 1
```

Note: *The short form is marked by upper-case letters, the long form corresponds to the complete word. Upper-case and lower-case notation only serves to distinguish the two forms in the manual, the instrument itself does not distinguish upper-case and lower-case letters.*

Parameters

Parameters must be separated from the header by a "white space". If several parameters are specified in a command, they are separated by a comma ",". A few queries permit the parameters MINimum, MAXimum and DEFault. For a description of the types of parameter, refer to section, "Parameters".

Example:
```
[:SOURce]:CLOCk frequency[,mode]
```

This command defines the clock rate (`frequency`) for reading samples from the output memory in various modes.

Numeric suffix

If a device features several functions or features of the same kind, e.g. outputs, the desired function can be selected by a suffix added to the command. Entries without suffix are interpreted like entries with the suffix 1.

Example:
```
:OUTPut:MARKer<2> ON
```

This command activates marker output no. 2.

Structure of a Command Line

A command line may consist of one or several commands. It is terminated by a <New Line>, a <New Line> with EOI or an EOI together with the last data byte. Quick BASIC automatically produces an EOI together with the last data byte.

Several commands in a command line must be separated by a semicolon ";". If the next command belongs to a different command system, the semicolon is followed by a colon.

Example:
```
CALL IECOUT("MMEM:LOAD RAM,'SINE';:OUTP:I FIX")
```

This command line contains two commands. The first command belongs to the `MMEMory` system and loads the SINE.WV waveform. The second command belongs to the `OUTPut` system and sets the I channel to FIX (V_{pp} = 1 V into 50 Ω).

If the successive commands belong to the same system, having one or several levels in common, the command line can be abbreviated. To this end, the second command after the semicolon starts with the level that lies below the common levels (see also Fig. 5-1). The colon following the semicolon must be omitted in this case.

Example:
```
CALL IECOUT("MMEM:MSIS 'C:';:MMEM:LOAD RAM,'SINE'")
```

This command line, which is shown in its full length, contains two commands separated by a semicolon and a colon. Both commands belong to the `MMEMory` system, i.e. they have a level in common, so the command line can be abbreviated.
In the abbreviated form, the second command starts at the level below `MMEM:`, i.e. with `LOAD`. The colon after the semicolon is omitted.
The abbreviated command line reads as follows:

```
CALL IECOUT("MMEM:MSIS 'C:';LOAD RAM,'SINE'")
```

Each new command line must start with the complete path, however.

Example:
```
CALL IECOUT("MMEM:MSIS 'C:'")
CALL IECOUT("MMEM:LOAD RAM, 'SINE")
```

Responses to Queries

A query is defined for each setting command unless explicitly specified otherwise. It is formed by adding a question mark to the associated setting command. According to SCPI, the responses to queries are partly subject to stricter rules than in standard IEEE 488.2.

1. The requested parameter is transmitted without header.

Example: `:OUTPut:I[:STATe]?` Response: `OFF`

2. Maximum values, minimum values and all further quantities, which are requested via a special text parameter are returned as numerical values.(not used in AMIQ)
3. Numerical values are output without a unit. Physical quantities are referred to the basic units or to the units set using the Unit command.

Example: `:OUTPut:I:AMPlitude?` Response: `1` for 1 V

4. Boolean values are returned as 0 (for OFF) and 1 (for ON).

Example: `:SYSTem:BEEPer:STATe?` Response: `1`

5. Text (character data) is returned in short form (see also section "Parameters").

Example: `OUTPut:FILTer?` Response: `EXT`

Parameters

Most commands require a parameter to be specified. The parameters must be separated from the header by a "white space". Permissible parameters are numerical values, Boolean parameters, text, character strings and block data. The type of parameter required for the respective command and the permissible range of values are specified in the command description.

Numerical values Numerical values can be entered in any form, i.e. with sign, decimal point and exponent. Values exceeding the resolution of the instrument are rounded up or down. The mantissa may comprise up to 255 characters, the exponent must lie inside the value range -32000 to 32000. The exponent is introduced by an "E" or "e". Entry of the exponent alone is not permissible. In the case of physical quantities, the unit can be entered. Permissible unit prefixes are G (giga), MA (mega), MOHM and MHZ are also permissible), K (kilo), M (milli), U (micro) and N (nano). It the unit is missing, the basic unit is used.

Example:
```
:OUTPut:I:AMPlitude 0.01 V      is equivalent to
:OUTPut:I:AMPlitude 1E-4
```

Special numerical values

The texts MINimum, MAXimum, DEFault, UP and DOWN are interpreted as special numerical values (not used in the AMIQ).

In the case of a query, the associated numerical value is provided.

Example: Setting command: `:SENSE2:POWer:REFerence MAXimum`
Query: `:SENSE2:POWer:REFerence?`
Response: `100MW`

MIN/MAX — MINimum and MAXimum denote the minimum and maximum value.

DEF — DEFault denotes a preset value. This value conforms to the default setting, as it is called by the *RST command.

UP/DOWN — UP, DOWN increases or reduces the numerical value by one step. The step width can be specified via an allocated step command (see chapter 6, "List of Commands") for each parameter which can be set via UP, DOWN.

INF/NINF — INFinity, Negative INFinity (NINF) represent the numerical values -9.9E37 or 9.9E37, respectively. INF and NINF are only sent as device responses.

NAN — Not a Number (NAN) represents the value 9.91E37. NAN is only sent as device response. This value is not defined. Possible causes are division of zero by zero, subtraction of infinite from infinite and the representation of missing values.

Boolean Parameters

Boolean parameters represent two states. The ON state (logically true) is represented by ON or a numerical value unequal to 0. The OFF state (logically untrue) is represented by OFF or the numerical value 0. 0 or 1 is provided in a query.

Example: Setting command: `:OUTPut:CLOCk ON`
Query: `:OUTPut:CLOCk?`
Response: `1`

Text

Text parameters observe the syntactic rules for key words, i.e. they can be entered using a short or long form. Like any parameter, they have to be separated from the header by a white space. In the case of a query, the short form of the text is provided.

Example: Setting command: `:OUTPut:FILTer EXTernal`
Query: `:OUTPut:FILTer?` Response: `EXT`

Strings

Strings must always be entered within quotation marks (' or ").

Example: `:MMEM:... "winiqsim\foobar"` or
`:MMEM:... 'winiqsim\foobar'`

Block data

Block data is a transmission format which is suitable for the transmission of large amounts of data. A command using a block data parameter has the following structure:

Example: `:HEADer:HEADer #45168xxxxxxxx`

The double dagger (ASCII character #) introduces the data block. The next number indicates how many of the following digits describe the length of the data block. In the example the 4 following digits indicate the length to be 5168 bytes. The data bytes follow. During the transmission of these data bytes all delimiters or other control characters are ignored until all bytes are transmitted.

Overview of Syntax Elements

The following survey offers an overview of the syntax elements.

:	The colon separates the key words of a command. In a command line the separating semicolon marks the uppermost command level.
;	The semicolon separates two commands of a command line. It does not alter the path.
,	The comma separates several parameters of a command.
?	The question mark forms a query.
*	The asterisk marks a common command.
"	Quotation marks introduce a string and terminate it.
#	The double dagger (ASCI character #) introduces block data.
	A "white space" (ASCII-Code 0 to 9, 11 to 32 decimal, e.g. blank) separates header and parameter.

Instrument Model and Command Processing

The instrument model shown in Fig. 5-2 has been made viewed from the standpoint of the servicing of IEC bus commands. The individual components work independently of each other and simultaneously. They communicate by means of so-called "messages".

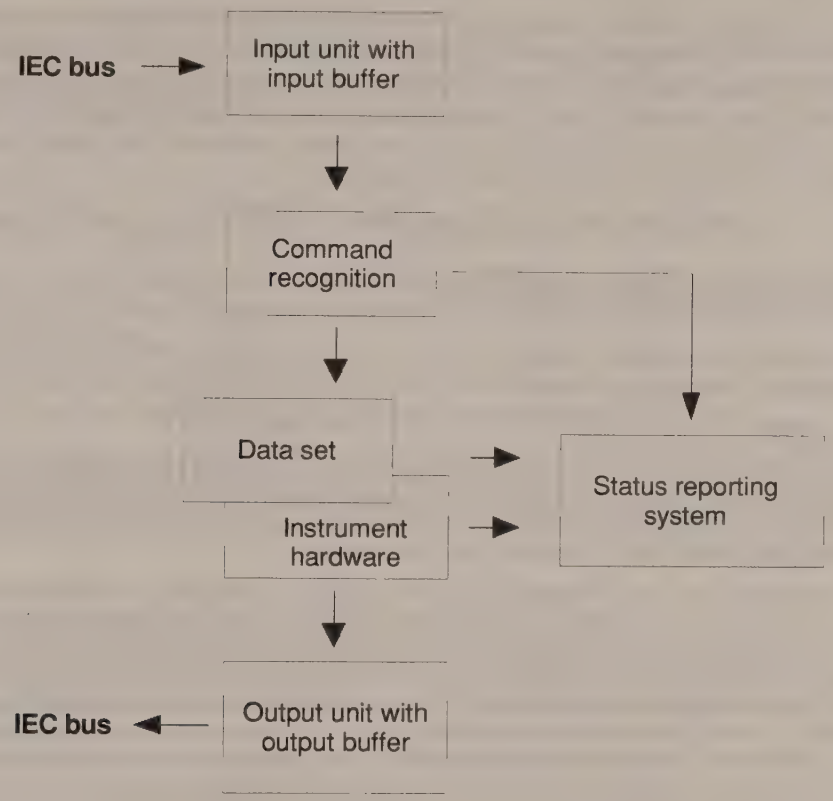


Fig. 5-2 Instrument model in the case of remote control by means of the IEC bus

Input Unit

The input unit receives commands character by character from the IEC bus and collects them in the input buffer. The input unit sends a message to the command recognition as soon as the input buffer is full or as soon as it receives a delimiter, <PROGRAM MESSAGE TERMINATOR>, as defined in IEEE 488.2, or the interface message DCL.

If the input buffer is full, the IEC bus traffic is stopped and the data received up to then are processed. Subsequently the IEC bus traffic is continued. If, however, the buffer is not yet full when receiving the delimiter, the input unit can already receive the next command during command recognition and execution. The receipt of a DCL clears the input buffer and immediately initiates a message to the command recognition.

Command Recognition

The command recognition analyses the data received from the input unit. It proceeds in the order in which it receives the data. Only a DCL is serviced with priority, a GET (Group Execute Trigger), e.g., is only executed after the commands received before. Each recognized command is immediately transmitted to the data set but not executed immediately.

Syntactical errors in the command are recognized here and transferred to the status reporting system. The rest of a command line after a syntax error is analyzed further as far as possible and serviced.

If the command recognition recognizes a delimiter or a DCL, it requests the data set to set the commands in the instrument hardware as well. Subsequently it is immediately prepared to process commands again. This means for the command servicing that further commands can already be serviced while the hardware is still being set ("overlapping execution").

Data Set and Instrument Hardware

The expression "instrument hardware" denotes the part of the instrument fulfilling the actual instrument function - signal generation, measurement etc. The controller is not included.

The data set is a detailed software reproduction of the instrument hardware.

IEC bus setting commands lead to an alteration in the data set. The data set management enters the new values (e.g. frequency) into the data set, however, only passes them on to the hardware when requested by the command recognition. As this is always only effected at the end of a command line, the order of the setting commands in the command line is not relevant.

The data are only checked for their compatibility among each other and with the instrument hardware immediately before they are transmitted to the instrument hardware. If the detection is made that execution is not possible, an "execution error" is signaled to the status reporting system. All alterations of the data set are canceled, the instrument hardware is not reset. Due to the delayed checking and hardware setting, however, impermissible instrument states can be set for a short period of time within one command line without this leading to an error message (example: simultaneous activation of FM and PM). At the end of the command line, however, a permissible instrument state must have been reached again.

Before passing on the data to the hardware, the settling bit in the STATus:OPERation register is set (cf. section STATus:OPERation Register). The hardware executes the settings and resets the bit again as soon as the new state has settled. This fact can be used to synchronize command servicing.

IEC bus queries induce the data set management to send the desired data to the output unit.

Status Reporting System

The status reporting system collects information on the instrument state and makes it available to the output unit on request. The exact structure and function are described in section "Status Reporting System" below.

Output Unit

The output unit collects the information requested by the controller, which it receives from the data set management. It processes it according to the SCPI rules and makes it available in the output buffer. If the information requested is longer, it is made available "in portions" without this being recognized by the controller.

If the instrument is addressed as a talker without the output buffer containing data or awaiting data from the data set management, the output unit sends error message "Query UNTERMINATED" to the status reporting system. No data are sent on the IEC bus, the controller waits until it has reached its time limit. This behavior is specified by SCPI.

Command Sequence and Command Synchronization

What was said above makes clear that overlapping execution is possible in principle for all commands. Equally, setting commands within one command line are not absolutely serviced in the order in which they have been received.

In order to make sure that commands are actually carried out in a certain order, each command must be sent in a separate command line, that is to say, with a separate IBWRT()-call.

In order to prevent an overlapping execution of commands, one of commands *OPC, *OPC? or *WAI must be used. All three commands cause a certain action only to be carried out after the hardware has been set and has settled. By a suitable programming, the controller can be forced to wait for the respective action to occur (cf. Table 5-1).

Table 5-1 Synchronization with *OPC, *OPC? and *WAI

Command	Action after the hardware has settled	Programming the controller
*OPC	Setting the operation-complete bit in the ESR	- Setting bit 0 in the ESE - Setting bit 5 in the SRE - Waiting for service request (SRQ)
*OPC?	Writing a "1" into the output buffer	Addressing the instrument as a talker
*WAI	Executing the next command Note: The IEC bus handshake is not stopped	Sending the next command

An example for command synchronization can be found in chapter 7, "Programming Examples".

Status Reporting System

The status reporting system (cf.Fig. 5-4) stores all information on the present operating state of the instrument, e.g. that the instrument presently carries out an AUTORANGE and on errors which have occurred. This information is stored in the status registers and in the error queue. The status registers and the error queue can be queried via IEC bus.

The information is of a hierarchical structure. The register status byte (STB) defined in IEEE 488.2 and its associated mask register service request enable (SRE) form the uppermost level. The STB receives its information from the standard event status register (ESR) which is also defined in IEEE 488.2 with the associated mask register standard event status enable (ESE) and registers STATus:OPERation and STATus:QUEStionable which are defined by SCPI and contain detailed information on the instrument.

The IST flag ("Individual STatus") and the parallel poll enable register (PPE) allocated to it are also part of the status reporting system. The IST flag, like the SRQ, combines the entire instrument status in a single bit. The PPE fulfills an analog function for the IST flag as the SRE for the service request.

The output buffer contains the messages the instrument returns to the controller. It is not part of the status reporting system but determines the value of the MAV bit in the STB and thus is represented in Fig. 5-4.

Structure of an SCPI Status Register

Each SCPI register consists of 5 parts which each have a width of 16 bits and have different functions (cf. Fig. 5-3). The individual bits are independent of each other, i.e. each hardware status is assigned a bit number which is valid for all five parts. For example, bit 3 of the STATus:OPERation register is assigned to the hardware status "wait for trigger" in all five parts. Bit 15 (the most significant bit) is set to zero for all parts. Thus the contents of the register parts can be processed by the controller as positive integer.

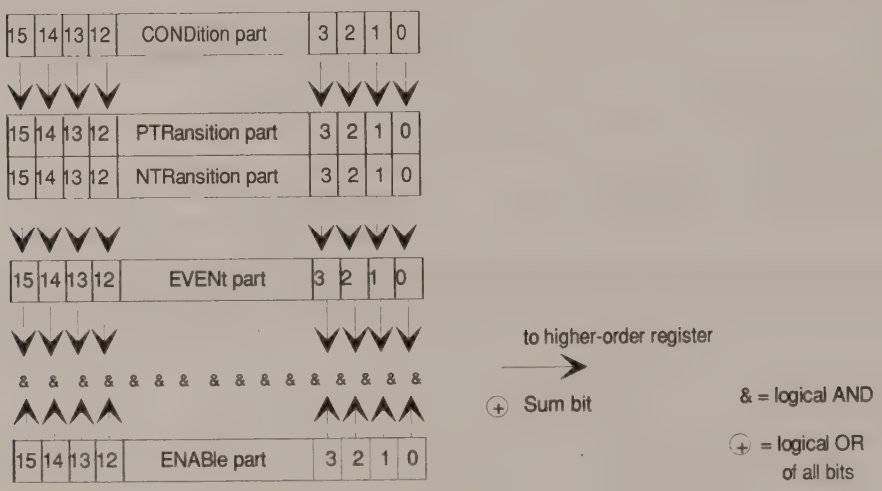

15 14 13 12 CONDition part 3 2 1 0
15 14 13 12 PTRansition part 3 2 1 0
15 14 13 12 NTRansition part 3 2 1 0
15 14 13 12 EVENt part 3 2 1 0
& & & & & & & & & & & & & &
15 14 13 12 ENABle part 3 2 1 0
to higher-order register
⊕ Sum bit
& = logical AND
⊕ = logical OR of all bits

Fig. 5-3 The status register model

CONDition part

The CONDition part is directly written into by the hardware or the sum bit of the next lower register. Its contents reflects the current instrument status. This register part can only be read, but not written into or cleared. Its contents is not affected by reading.

PTRansition part

The Positive-TRansition part acts as an edge detector. When a bit of the CONDition part is changed from 0 to 1, the associated PTR bit decides whether the EVENt bit is set to 1.
PTR bit =1: the EVENt bit is set.
PTR bit =0: the EVENt bit is not set.
This part can be written into and read at will. Its contents is not affected by reading.

NTRansition part

The Negative-TRansition part also acts as an edge detector. When a bit of the CONDition part is changed from 1 to 0, the associated NTR bit decides whether the EVENt bit is set to 1.
NTR bit =1: the EVENt bit is set.
NTR bit =0: the EVENt bit is not set.
This part can be written into and read at will. Its contents is not affected by reading.

With these two edge register parts the user can define which state transition of the condition part (none, 0 to 1, 1 to 0 or both) is stored in the EVENt part.

EVENt part

The EVENt part indicates whether an event has occurred since the last reading, it is the "memory" of the condition part. It only indicates events passed on by the edge filters. It is permanently updated by the instrument. This part can only be read by the user. Upon reading, its contents is set to zero. In colloquial language, this part is often equated with the entire register.

ENABle part

The ENABle part determines whether the associated EVENt bit contributes to the sum bit (cf. below). Each bit of the EVENt part is ANDed with the associated ENABle bit (symbol '&'). The results of all logical operations of this part are passed on to the sum bit via an OR function (symbol '+').
ENAB bit =0: the associated EVENt bit does not contribute to the sum bit
ENAB bit =1: if the associated EVENT bit is "1", the sum bit is set to "1" as well.
This part can be written into and read by the user at will. Its contents is not affected by reading.

Sum bit

As indicated above, the sum bit is obtained from the EVENt and ENABle part for each register. The result is then entered into a bit of the CONDition part of the higher-order register.
The instrument automatically generates the sum bit for each register. Thus an event, e.g. a PLL that has not locked, can lead to a service request throughout all levels of the hierarchy.

Note:

The service request enable register SRE defined in IEEE 488.2 can be taken as ENABle part of the STB if the STB is structured according to SCPI. By analogy, the ESE can be taken as the ENABle part of the ESR.

Overview of Status Registers

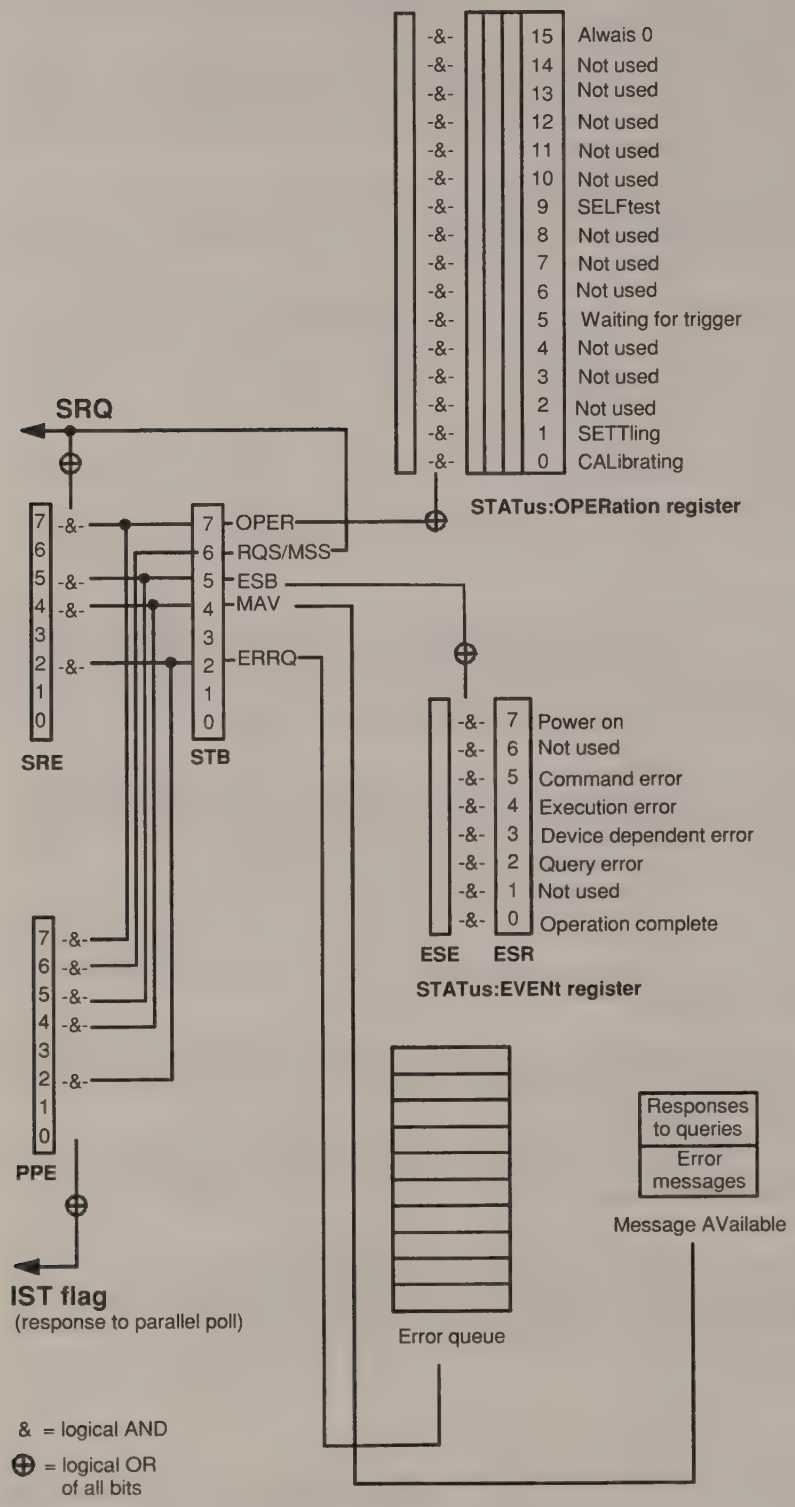


Fig. 5-4 The Status registers

Description of the Status Registers

Status Byte (STB) and Service Request Enable Register (SRE)

The STB is already defined in IEEE 488.2. It provides a rough overview of the instrument status by collecting the pieces of information of the lower registers. It can thus be compared with the CONDition part of an SCPI register and assumes the highest level within the SCPI hierarchy. A special feature is that bit 6 acts as the sum bit of the remaining bits of the status byte.

The STATUS BYTE is read out using the command "*STB?" or a serial poll.

The STB is linked to the SRE. The latter corresponds to the ENABle part of the SCPI registers in its function. Each bit of the STB is assigned a bit in the SRE. Bit 6 of the SRE is ignored. If a bit is set in the SRE and the associated bit in the STB changes from 0 to 1, a Service Request (SRQ) is generated on the IEC bus, which triggers an interrupt in the controller if this is appropriately configured and can be further processed there.
The SRE can be set using command "*SRE" and read using "*SRE?".

Table 5-2 Meaning of the bits used in the status byte

Bit no.	Meaning
2	**Error Queue not empty** The bit is set when an entry is made in the error queue. If this bit is enabled by the SRE, each entry of the error queue generates a Service Request. Thus an error can be recognized and specified in greater detail by polling the error queue. The poll provides an informative error message. This procedure is to be recommended since it considerably reduces the problems involved with IEC bus control.
3	vacant
4	**MAV-Bit** (Message AVailable) The bit is set if a message is available in the output buffer which can be read. This bit can be used to enable data to be automatically read from the instrument to the controller (cf. chapter 7, "Programming Examples").
5	**ESB bit** Sum bit of the event status register. It is set if one of the bits in the event status register is set and enabled in the event status enable register. Setting of this bit indicates a serious error which can be specified in more detail by polling the event status register.
6	**MSS-Bit** (Master Status Summary bit) The bit is set if the instrument triggers a service request. This is the case if one of the other bits of this register is set together with its mask bit in the service request enable register SRE.
7	**OPERation status register sum bit** The bit is set if an EVENt bit is set in the OPERation status register and the associated ENABle bit is set to 1. A set bit indicates that the instrument is just performing an action. The type of action can be queried by polling the OPERation status register.

IST Flag and Parallel Poll Enable Register (PPE)

By analogy with the SRQ, the IST flag combines the entire status information in a single bit. It can be queried by means of a parallel poll (cf. section "Parallel Poll") or using the command "`*IST?`".

The parallel poll enable register (PPE) determines which bits of the STB contribute to the IST flag. The bits of the STB are ANDed with the corresponding bits of the PPE, with bit 6 being used as well in contrast to the SRE. The IST flag results from the ORing of all results. The PPE can be set using commands "*PRE" and read using command "`*PRE?`".

Event Status Register (ESR) and Event Status Enable Register (ESE)

The ESR is already defined in IEEE 488.2. It can be compared with the EVENt part of an SCPI register. The event status register can be read out using command "`*ESR?`".
The ESE is the associated ENABle part. It can be set using the command "`*ESE`" and read using the command "`*ESE?`".

Table 5-3 Meaning of the bits used in the event status register

Bit No.	Meaning
0	**Operation Complete** This bit is set on receipt of the command *OPC exactly when all previous commands have been executed.
1	**Request Control** This bit is not used in the AMIQ.
2	**Query Error** This bit is set if either the controller wants to read data from the instrument without having sent a query, or if it does not fetch requested data and sends new instructions to the instrument instead. The cause is often a query which is faulty and hence cannot be executed.
3	**Device-dependent Error** This bit is set if a device-dependent error occurs. An error message with a number between -300 and -399 or a positive error number, which denotes the error in greater detail, is entered into the error queue (cf. chapter 9, "Error Messages").
4	**Execution Error** This bit is set if a received command is syntactically correct but cannot be performed for other reasons. An error message with a number between -200 and -300, which denotes the error in greater detail, is entered into the error queue (cf. chapter 9, "Error Messages").
5	**Command Error** This bit is set if a command which is undefined or syntactically incorrect is received. An error message with a number between -100 and -200, which denotes the error in greater detail, is entered into the error queue (cf. chapter 9, "Error Messages").
6	**User Request** This bit is not used in the AMIQ.
7	**Power On** (supply voltage on) This bit is set on switching on the instrument.

STATus:OPERation Register

In the CONDition part, this register contains information on which actions the instrument is being executing or, in the EVENt part, information on which actions the instrument has executed since the last reading. It can be read using one of the commands `"STATus:OPERation:CONDition?"` or `"STATus:OPERation [:EVENt]?"`..

Table 5-4 Meaning of the bits used in the STATus:OPERation register

Bit-No.	Meaning
0	**CALibrating** This bit is set as long as an internal adjustment routine is executed.
1	**SETTing** This bit is set as long as a new hardware status is settling after a setting command.
5	**Waiting for TRIGGER** This bit is set as long as the instrument is waiting for a trigger event.
9	**Selftest** This bit is set while the instrument executes the command `*TST?` or one of the commands `DIAG:SELF:xxx?`

STATus:QUEStionable Register

This register contains information on questionable instrument states. They can occur, e.g. if the instrument is operated outside its specified range. It can be queried using one of the commands `":STATus:QUEStionable:CONDition?"` or `":STATus:QUEStionable[:EVENt]?"`.

Table 5-5 Meaning of the bits used in the STATus:QUEStionable register

Bit-No.	Meaning
	At present, no bits of this register are used in the AMIQ

Application of the Status Reporting System

In order to effectively use the status reporting system, the information contained there must be transmitted to the controller to be further processed. There are several methods which are outlined in the following. For detailed program examples, see chapter 7, "Programming Examples".

Service Request, Making Use of the Hierarchy Structure

Under certain circumstances, the instrument can send a service request (SRQ) to the controller. Usually this service request initiates an interrupt at the controller, to which the control program can react appropriately. As evident from Fig. 5-4, an SRQ is always initiated if one or several of bits 2, 3, 4, 5 or 7 of the status byte are set and enabled in the SRE. Each of these bits combines the information of a further register, the error queue or the output buffer. The corresponding setting of the ENABle parts of the status registers can achieve that arbitrary bits in an arbitrary status register initiate an SRQ. In order use the possibilities of the service request effectively, all bits should be set to "1" in the enable registers SRE and ESE.

Examples (cf.Fig. 5-3, section Overview of Status Registers and chapter 7, "Programming examples"):

Use command "`*OPC`" to generate an SRQ:

- Set bit 0 in the ESE (Operation Complete)
- Set bit 5 in the SRE (ESB)

  After its settings have been completed, the instrument generates an SRQ.

Indication of the end of a measurement by means of an SRQ with the controller:

- Set bit 7 in the SRE (sum bit of the STATus:OPERation register)
- Set bit 4 (measuring) in the STATus:OPERation:ENABle.
- Set bit 4 in the STATus:OPERation:NTRansition so as to make sure that the transition of measuring bit 4 from 1 to 0 (end of measurement) is recorded in the EVENt part.

  After a sweep has been completed, the instrument generates an SRQ.

The SRQ is the only possibility for the instrument to become active on its own. Each controller program should set the instrument such that a service request is initiated in the case of malfunction. The program should react appropriately to the service request. A detailed example for a service request routine can be found in chapter 7, "Programming examples".

Serial Poll

In a serial poll, just as upon the command "*STB", the status byte of an instrument is queried. However, the query is made via interface messages and is thus clearly faster. The serial-poll method has already been defined in IEEE 488.1 and used to be the only standard possibility for different instruments to poll the status byte. The method also works for instruments which do not adhere to SCPI or IEEE 488.2.

The quick-BASIC command for executing a serial poll is "IBRSP()". The serial poll is mainly used to obtain a fast overview of the state of several instruments connected to the IEC bus.

Parallel Poll

In a parallel poll, up to eight instruments are simultaneously requested by the controller by means of a single command to transmit 1 bit of information each on the data lines, i.e., to set the data line allocated to each instrument to a logic "0" or "1". By analogy to the SRE register which determines under which conditions an SRQ is generated, there is a parallel poll enable register (PPE) which is ANDed with the STB bit by bit, considering bit 6 – AND as well. The results are ORed, the result is then sent (possibly inverted) as a response to the parallel poll of the controller. The result can also be queried without parallel poll by means of the command "*IST".

The instrument first has to be set for the parallel poll using the quick-BASIC command "IBPPC()". This command allocates a data line to the instrument and determines whether the response is to be inverted. The parallel poll itself is executed using "IBRPP()".

The parallel-poll method is mainly used in order to quickly find out after an SRQ which instrument has sent the service request if there are many instruments connected to the IEC bus. To this effect, SRE and PPE must be set to the same value. A detailed example for a parallel poll can be found in chapter 7, "Programming Examples".

Query by Means of Commands

Each part of any status register can be read by means of queries. The individual commands are listed in the detailed description of the registers in section Overview of Status Registers. What is returned is always a number which represents the bit pattern of the register queried. Evaluating this number is effected by the controller program.

Queries are usually used after an SRQ in order to obtain more detailed information on the cause of the SRQ.

Error Queue Query

Each error state in the instrument leads to an entry in the error queue. The entries of the error queue are detailed plain-text error messages which can be looked at in the ERROR menu via manual control or queried via the IEC bus using command "SYSTem:ERRor?". Each call of "SYSTem:ERRor?" provides one entry from the error queue. If no error messages are stored there any more, the instrument responds with 0, "No error"

The error queue should be queried after every SRQ in the controller program as the entries describe the cause of an error more precisely than the status registers. Especially in the test phase of a controller program the error queue should be queried regularly since faulty commands from the controller to the instrument are recorded there as well.

Reset Values of the Status Reporting Systems

Table5-6 summarizes the different commands and events causing the status reporting system to be reset. None of the commands, except `*RST` and `SYSTem:PRESet` influences the functional instrument settings. In particular, `DCL` does not change the instrument settings.

Table5-6 Resetting instrument functions

Event / Effect	Switching on supply voltage: Power-On-Status-Clear 0	Switching on supply voltage: Power-On-Status-Clear 1	DCL,SDC (Device Clear, Selected Device Clear)	*RST or SYSTem:PRESet	STATus:PRESet	*CLS
Clear STB,ESR	—	yes	—	—	—	yes
Clear SRE,ESE	—	yes	—	—	—	—
Clear PPE	—	yes	—	—	—	—
Clear EVENt parts of the registers	—	yes	—	—	—	yes
Clear ENABle parts of all OPERation-and QUESTionable registers, Fill ENABle parts of all other registers with "1".	—	yes	—	—	yes	—
Fill PTRansition parts with „1" Clear NTRansition parts	—	yes	—	—	yes	—
Clear error queue	yes	yes	—	—	—	yes
Clear output buffer	yes	yes	yes	1)	1)	1)
Clear command processing and input buffer	yes	yes	yes	—	—	—

1) Every command being the first in a command line, i.e. immediately following a <PROGRAM MESSAGE TERMINATOR> clears the output buffer.

Hardware Interfaces

IEC/IEEE Bus Interface

The standard instrument is equipped with an IEC/IEEE-bus connection. The IEEE 488 interface connector is located on the rear panel of the instrument. A controller for remote control can be connected via the IEEE 488 interface using a shielded cable.

Characteristics of the Interface

- 8-bit parallel data transfer,
- bidirectional data transfer,
- three line handshake,
- high data transfer rate of max. 350 kByte/s,
- up to 15 devices can be connected,
- maximal length of the connecting cables 15 m (single connection 2 m),
- wired OR if several instruments are connected in parallel.

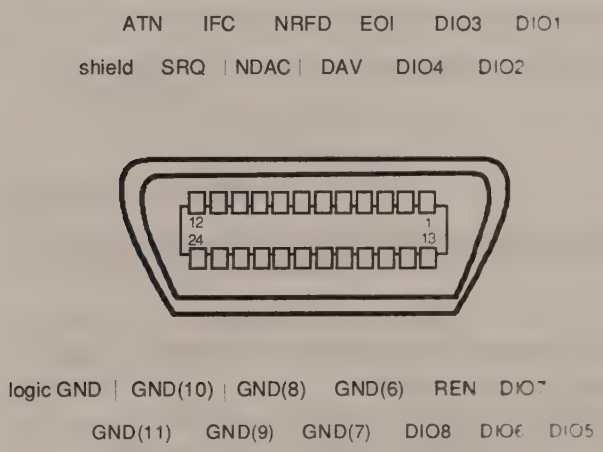


Fig. 5-5 Pin Assigment of the IEC-bus interface

Bus Lines

1. Data bus with 8 lines DIO 1 to DIO 8.

The transmission is bit-parallel and byte-serial in the ASCII/ISO code. DIO1 is the least significant bit, DIO8 the most significant bit.

2. Control bus with 5 lines

IFC (Interface Clear),
active LOW resets the interfaces of the instruments connected to the default setting.

ATN (Attention),
active LOW signals the transmission of interface messages
inactive HIGH signals the transmission of device messages.

SRQ (Service Request),
active LOW enables the connected device to send a service request to the controller.

REN (Remote Enable),
active LOW permits switchover to remote control.

EOI (End or Identify),
has two functions in connection with ATN:
ATN=HIGH active LOW marks the end of data transmission.
ATN=LOW active LOW triggers a parallel poll.

3. Handshake bus with three lines

DAV (Data Valid),
active LOW signals a valid data byte on the data bus.

NRFD (Not Ready For Data),
active LOW signals that one of the connected devices is not ready for data transfer.

NDAC (Not Data Accepted),
active LOW signals that the instrument connected is accepting the data on the data bus.

Interface Functions

Instruments which can be controlled via IEC bus can be equipped with different interface functions.

Table 5-7 Interface functions

Control character	Interface function
SH1	Handshake source function (source handshake)
AH1	Handshake drain function (acceptor handshake)
L4	Listener function
T6	Talker function, ability to respond to serial poll
SR1	Service request function
PP1	Parallel poll function
RL1	Remote/Local switchover function
DC1	Reset function (Device Clear)
DT1	Trigger function (Device Trigger)

Interface Messages

Interface messages are transmitted to the instrument on the data lines, with the attention line being active (LOW). They serve to communicate between controller and instrument.

Universal Commands

Universal commands are encoded in the range 10 through 1F hex. They are effective for all instruments connected to the bus without pervious addressing.

Table 5-8 Universal Commands

Command	QuickBASIC command	Effect on the instrument
DCL (Device Clear)	IBCMD (controller%, CHR$(20))	Aborts processing of the commands just received and sets the command processing software to a defined initial state. Does not change the instrument setting.
IFC (Interface Clear)	IBSIC (controller%)	Resets the interfaces to the default setting.
LLO (Local Lockout)	IBCMD (controller%, CHR$(17))	The LOC/IEC ADDR key is disabled.
SPE (Serial Poll Enable)	IBCMD (controller%, CHR$(24))	Ready for serial poll.
SPD (Serial Poll Disable)	IBCMD (controller%, CHR$(25))	End of serial poll.
PPU (Parallel Poll Unconfigure)	IBCMD (controller%, CHR$(21))	End of the parallel-poll state.

Addressed Commands

Addressed commands are encoded in the range 00 through 0F hex. They are only effective for instruments addressed as listeners.

Table 5-9 Addressed Commands

Command	QuickBASIC command	Effect on the instrument
SDC (Selected Device Clear)	IBCLR (device%)	Aborts processing of the commands just received and sets the command processing software to a defined initial state. Does not change the instrument setting.
GET (Group Execute Trigger)	IBTRG (device%)	Triggers a previously active device function. The effect of the command is the same as with that of a pulse at the external trigger signal input.
GTL (Go to Local)	IBLOC (device%)	Transition to the "Local" state (manual control).
PPC (Parallel Poll Configure)	IBPPC (device%, data%)	Configure instrument for parallel poll. The QuickBASIC command additionally executes PPE / PPD.

RS-232-C Interface

The standard instrument is equipped with an RS-232-C interface. The 9-pin connector is located on the rear panel. A controller can be connected via this interface for remote control.

Interface characteristics

- Serial data transmission in asynchronous mode,
- Bidirectional data transmission via two separate lines,
- Transmission rate selectable from 300 to 115200 baud,
- Logic 0 signal from +3 V to +15 V,
- Logic 1 signal from -15 V to -3 V,
- An external instrument (controller) can be connected,
- Hardware handshake RTS/CTS set.

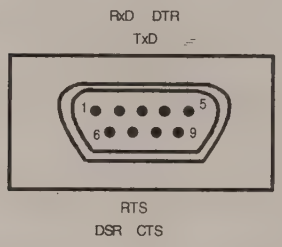


Fig. 5-6 Pin assigment of the RS-232-C interface

Signal lines

RxD (Receive Data),
Input; data line for transmitting from remote station to local terminal.

TxD (Transmit Data),
Output; data line for transmitting from local terminal to remote station.

DTR (Data Terminal Ready),
Output (log. '0' = active); with DTR, the instrument indicates that it is ready to receive data.

GND (Ground),
Interface ground, connected to instrument ground.

DSR (Data set ready),
Input (log. '0' = active); DSR indicates to the instrument that the remote station is ready to receive data.

RTS (Request to send),
Output (log. '0' = active); with RTS, the instrument indicates that it is ready to receive data. The RTS line controls whether the instrument is ready to receive data or not.

CTS (Clear to send),
Input (log. '0' = active); CTS tells the instrument that the remote station is ready to receive data.

Transmission parameters

In order to ensure error-free and correct data transmission, the parameters of the instrument and the controller must be set identically.

Transmission rate (baud rate)

Baud rates ranging from 1200 to 115200 can be set in the instrument: see chapter 6, `:SYSTem:COMMunicate:SERial:Baud`.

Data bits

Data transmission is in 8-bit ASCII code. The first bit transmitted is the LSB (Least Significant Bit).

Start bit

Each data byte begins with a start bit. The falling edge of the start bit indicates the beginning of the data byte.

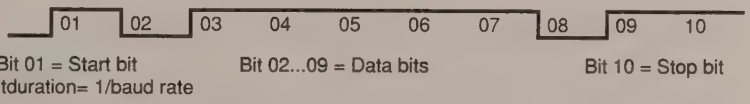
Parity bit

No parity bit is used.

Stop bit

The transmission of a data byte is terminated by a stop bit.

Example:
Transmission of character A (41 hex) in the 8-bit ASCII code.



Bit 01 = Start bit
Bitduration= 1/baud rate

Bit 02...09 = Data bits

Bit 10 = Stop bit

Interface functions

For interface control, some control characters from the ASCII code range of 0 to 20 hex are predefined and can be transmitted via the interface (see Table A-4).

Table 5-10 Control strings or control characters of the RS-232-C interface

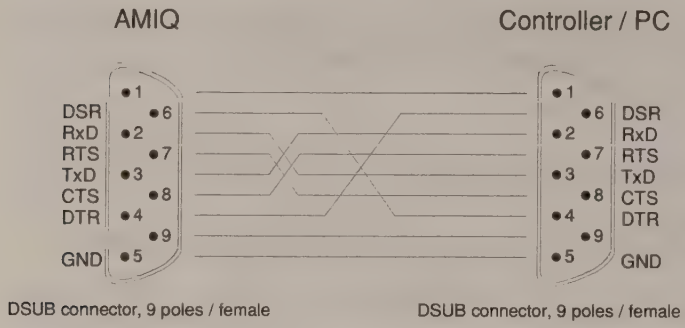
Control Character	Function
Break (at least 1 character only log 0)	Reset of instrument Waiting time until output of new command: 100 ms
0Dhex, 0Ahex	Terminator of commands <CR>, <LF> Switchover between local and remote

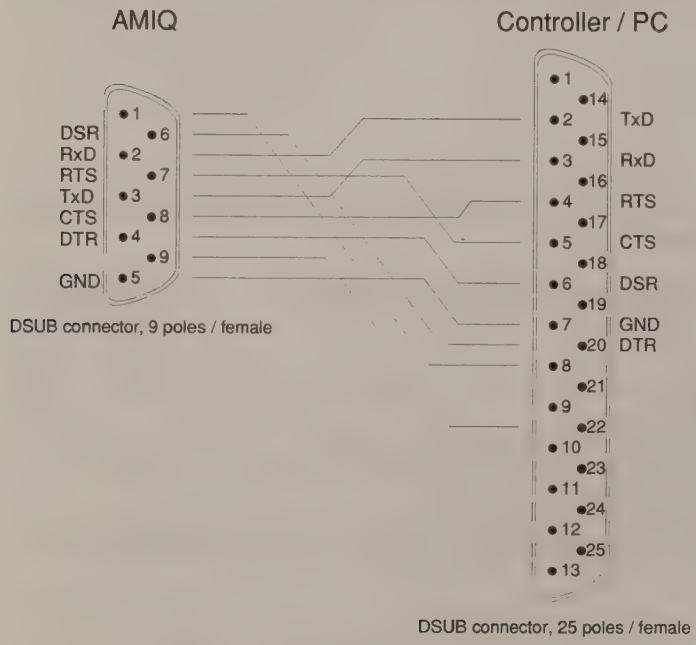
Handshake

Hardware handshake

In case of a hardware handshake, the instrument signals that it is ready for reception via line DTR and RTS. A logic '0' means "ready" and a '1' means "not ready".

The CTS or DSR lines (see signal lines) tell the instrument whether the controller is ready for reception or not. The transmitter of the instrument is switched on by a '0' and switched off by a '1'. The RTS line remains active as long as the serial interface is active. The DTR line controls whether the instrument is ready for reception or not.





Connection between instrument and controller (Null-modem cable)

The connection of the instrument to a controller is made with a so-called null-modem cable. Here, the data, control and signalling lines must be crossed. The wiring diagram on the left applies to a controller with a 9-pin or 25-pin configuration.

Fig. 5-7 Null-modem connection scheme

6 Remote Control – Commands and Data Formats

In the following sections, all remote control commands of the AMIQ are first listed in tables and then described in detail, separated according to the command systems. The notation largely corresponds to the one of the SCPI standards.

All commands can be used for control via IEC/IEEE bus, the serial interface and via the batch files on floppies and the hard disk (see :PROGram subsystem).

In the detailed description always the shortest possible command line is given as an example for all commands, except common commands. The value specified for each command is the value set after an *RST. No values are required for queries and commands triggering an action (eg *CLS).

Notation

Table of commands

Command: The *command* column provides an overview of the commands and their hierarchical arrangement.

Parameters: The *parameters* column indicates the requested parameters together with their specified range.

Remark: In the remark column, all commands are indicated

- which do not have a query form,
- which have only one query form ,
- which are implemented only in conjunction with a certain option of the instrument.

Upper/lower case characters

Upper/lower case characters serve to mark the long or short form of the keywords of a command. The shortform consists of upper case characters, the long form comprises upper/lower case characters. Only these two forms are permissible. The instrument itself does not distinguish between upper and lower case characters.

Special characters |

A selection of *keywords* with identical effect exists for several commands. These keywords are indicated in the same line, they are separated by a vertical stroke. Only one of these keywords has to be specified in the header of the command. The effect of the command is independent of which of the keywords is specified.

:MMEMory	first level
:CD | CDIRectory	second level

A vertical stroke between the *parameters* marks alternative options in the sense of "or". The effect of the command is different, depending on which parameter is entered.

Example: Selection of the parameters for the command

:TRIGger:SLOPe RISing | HIGH

[ ] *Key words* in square brackets can be omitted when composing the header (see 78chapter 5, section "Structure of a Command" – Optional Keywords). The full command length must be accepted by the instrument for reasons of compatibility with the SCPI standards.

Parameters in square brackets are optional and can be omitted.

<n> This sign marks the numeric suffix, which identifies marker outputs, for instance.

<name> Angle brackets mark a character data parameter that has to be specified within quotation marks (""). For instance, *RCL <name> may become *RCL "sine".

Common Commands

The common commands are taken from the IEEE 488.2 (IEC 625.2) standard (except for those marked "not IEEE 488.2" which are device-specific extensions). They have the same effect on all devices. The headers of these commands consist of an asterisk * followed by three letters. Many common commands refer to the status reporting system which is described in detail in chapter 5, under "Status Reporting System".

Table 6-1 Common commands

Command	Parameters	Remark
*CLS		No query
*DCL		Not IEEE 488.2
*ESE	0 to 255	
*ESR?		Query only
*GTL		Not IEEE 488.2
*IDN?		Query only
*IST?		Query only
*OPC		
*OPT?		Query only
*RCL	<name>	
*RST		
*SAV	<name>	
*SRE	0 to 255	
*STB?		Query only
*TRG		
*TST?		Query only
*WAI		

***CLS**

CLEAR STATUS sets the status byte (STB), the Standard Event Register (ESR) and the EVENt-part of the QUEStionable and the OPERation register to zero. The command does not alter the mask and transition parts of the status registers. It clears the output buffer.

Example: `*CLS`

***DCL**

DEVICE CLEAR resets the remote control logic of the device to a defined default state. The command is equivalent to the line message Device Clear but can also be used via the serial interface. Device settings (loaded waveforms, output level, etc) are *not* changed.

Example: `*DCL`

***ESE 0 to 255**

EVENT STATUS ENABLE sets the Event Status Enable register to the value indicated. The query *ESE? returns the contents of the event status enable register in decimal representation.

Example: `*ESE 255` *RST value: 0

***ESR?**

EVENT STATUS REGISTER returns the contents of the Event Status Register in decimal representation and then sets the register to zero.

Example: `*ESR?`

***GTL**

GO TO LOCAL pseudo command. The GTL line message via the IEC/IEEE bus has the same function. After this command all remote control channels are active. The channel on which the next command arrives will be used.

This command is mainly intended for the serial interface. The interface message "gtl" should be used instead on the IEC/IEEE bus because, when the command *GTL is sent, the IEC/IEEE-bus talker function of the host will not notice that the device has changed to the local mode and requires to be newly addressed.

Example: `*GTL`

***IDN?**

IDENTIFICATION QUERY – The response of AMIQ is Rohde & Schwarz, AMIQ, ssssss/sss, x.yy, where ssssss/sss is the serial number and x.yy the software version.

Example: `*IDN?`

Response eg:

`"Rohde&Schwarz,AMIQ,123456/789,3.0"`	for AMIQ model 02
`"Rohde&Schwarz,AMIQ02,123456/789,3.0"`	for AMIQ model 02 with 03 board
`"Rohde&Schwarz,AMIQ03,123456/789,3.0"`	for AMIQ model 03
`"Rohde&Schwarz,AMIQ04,123456/789,3.0"`	for AMIQ model 04

***IST?**

INDIVIDUAL STATUS QUERY returns the contents of the IST flag in decimal form (0 or 1). The IST flag can also be queried by means of a Parallel Poll.

Example: `*IST?`

***OPC or *OPC?**

OPERATION COMPLETE sets bit 0 in the Event Status Register when all preceding commands have been executed. This bit can be used to initiate a Service Request, if bit 5 in the Status Enable Register is set. **Advantage of *OPC over *OPC?: The program can perform other tasks** while waiting for an SRQ after an "operation complete" bit has been set in the Event Status Register.

The query **OPC? returns a "1" as soon as all preceding commands have been executed. Thus the controller and the device can easily be synchronized. The "1" is insignificant however – the procedure is so that, for example, the "ibrd" instruction (function from National Instruments for reading data from the IEC/IEEE bus) stops program execution until a "1" is placed in the output buffer. Sending an *OPC? query is therefore not a suitable procedure for waiting for a "1" in a program loop. This can be done with *OPC.**

Example: `*OPC?`

***OPT?**

OPTION IDENTIFICATION QUERY returns a list of installed options separated by commas. A zero in the list indicates that an option is not installed. The following options are available at present:

- AMIQ-B1: BER Measurement
- AMIQB19: Rear I/Q Outputs
- AMIQ-B2: Differential I/Q Outputs
- AMIQK11: IS-95 CDMA
- AMIQ-B3: Digital I/Q Output
- AMIQK12: CDMA 2000 (from WinIQSIM Version 3.20)
- AMIQK13: not assigned
- AMIQK14: Digital Standard TD-SCDMA (from WinIQSIM Version 3.50)
- AMIQK15: OFDM Signal Generation (from WinIQSIM Version 3.40)

The query *OPT? returns the designations of all options installed **in the order given above.** Options not installed are designated "0". In the example below, the zeros indicate that options AMIQB19, AMIQK13 and AMIQK14 are not installed.

Example: `*OPT?` Response: AMIQB1,0,AMIQB2,AMIQK11,AMIQB3,AMIQK12,0,0,AMIQK15

***RCL <name>**

RECALL recalls the device status file (files with extension .CFG) from drive C: and sets the device status saved with *SAV under <name>. The extension .CFG may be omitted. It is not allowed to specify any drive names and paths; the default drive set via `MMEM:MSIS <drive>` is ignored. If <name> does not exist, an error message is generated. No distinction is made between upper and lower case letters for the parameter <name>.

A device status can be loaded from or saved to floppy disk and thus transferred to another device. See `SYSTem:STATe:COPY <source>,<dest>` command in the SYSTEM section (p. 6.47 ff).

Example: `*RCL "sinus"`

***RST**

RESET sets the device to a defined default state. If the *RST command is contained in a batch file, the file is not aborted. Some settings are not affected by *RST. This includes the IEC/IEEE-bus address, the transmission speed of the serial interface and the status registers.

Example: `*RST`

*RST default settings:

BERT:SET:CLOC **RIS**	MMEM:LOAD RAM ***NONE***	OUTP:MARK4:DEL **0**	SOUR:SCLO **INTERNAL**
BERT:SET:MCO **10000**	OUTP:CLOC **ON**	OUTP:MARK4:STAT **OFF**	SOUR:CORR:GAIN:I:FIX **0.0**
BERT:SET:DATA **NORM**	OUTP:DIG **OFF**	OUTP:OIMP **R50**	SOUR:CORR:GAIN:Q:FIX **0.0**
BERT:SET:MERR **100**	OUTP:I:AMPL **0.5**	OUTP:Q:AMPL **0.5**	SOUR:CORR:OFFS:I:FIX **0.0**
BERT:SET:MASK **OFF**	OUTP:I:AMPL:BAL **0.5**	OUTP:Q:AMPL:BAL **0.5**	SOUR:CORR:OFFS:I:VAR **0.0**
BERT:SET:REST **INT**	OUTP:I:FILT **25MHZ**	OUTP:Q:FILT **25MHZ**	SOUR:CORR:OFFS:Q:FIX **0.0**
BERT:SET:TYPE **PRBS9**	OUTP:I:STAT **OFF**	OUTP:Q:STAT **OFF**	SOUR:CORR:OFFS:Q:VAR **0.0**
MARK1:LIST **'0-0:0'**	OUTP:MARK1:DEL **0**	OUTP:RES **14**	SOUR:CORR:SKEW **0.0**
MARK2:LIST **'0-0:0'**	OUTP:MARK1:STAT **OFF**	OUTP:TYPE **UNB**	SOUR:ROSC:SOUR **INT**
MARK3:LIST **'0-0:0'**	OUTP:MARK2:DEL **0**	OUTP:I:BIAS **0**	SYST:BEEP:STAT **ON**
MARK4:LIST **'0-0:0'**	OUTP:MARK2:STAT **OFF**	OUTP:Q:BIAS **0**	TRIG:MODE **CONT**
MMEM:CDIR **'\'**	OUTP:MARK3:DEL **0**	SOUR:CLOC **3000000**	TRIG:SLOP **POS**
MMEM:MSIS **'C:'**	OUTP:MARK3:STAT **OFF**	SOUR:CLOC:MODE **SLOW**	TRIG:SOUR **BUS**

***SAV <name>**

SAVE saves the current device status as a device status file (files with the extension .CFG) with the specified name in drive C:. The extension .CFG may be omitted. It is not allowed to specify any drive names and paths; the default drive set via `MMEM:MSIS <drive>` is ignored. This status also comprises the name of the waveform file currently in the output buffer. The words *current* and *preset* are reserved and must not be used. If a device status with the specified name already exists, it is overwritten. Names may contain up to eight alphanumeric characters; no difference is made between upper and lower case characters. Up to 100 device states can be stored, then an error message is output and the command is not executed. In this case, entries in the memory must be cleared before a new *SAV command is sent. The save/recall memory is administered under :SYSTem:STATe.

A device status can be loaded from or saved to floppy disk and thus transferred to another device. See `MMEMory:COPY` command in this chapter!

Example: `*SAV "cdma"`

***SRE 0 to 255**

SERVICE REQUEST ENABLE sets the Service Request Enable Register to the defined value. Bit 6 (MSS mask bit) remains 0. This command determines under which conditions a service request is triggered. Query *SRE? outputs the contents of the Service Request Enable Register in decimal form. Bit 6 is always 0.

Example: `*SRE 191` *RST value: 0

***STB?**

STATUS BYTE QUERY reads out the contents of the status byte in decimal form.

Example: `*STB?`

***TRG**

TRIGGER starts the data output from the output buffer. Data output in progress is stopped and restarted.

Example: `*TRG*TST?`

***TST?**

TEST triggers a complete selftest of AMIQ. This includes approx. 50 internal tests and measurements yielding the ASCII result „0" if no error is detected. In case of an error, „1" is returned and a short beep sounds.

The selftest for AMIQ's SDRAM is not included in `*TST?` because of its long execution time of approx. 30 seconds for an AMIQ 03 (4.000.000 samples) and approx. 2 minutes for an AMIQ 04 (16.000.000 samples). It can be performed separately by the `DIAG:SELF:SDRam?` query (see DIAGnostic – Hardware Diagnosis on page 6.17).

Before the complete selftest is started the device status is automatically saved. It is restored after the selftest is completed. This implies that the time required for the selftest is extended by the time needed to restore the previous device status depending on the length of the loaded curve. To keep this time as short as possible it is recommended to load a short curve (e.g. SINE.WV) before calling up the selftest. With SINE.WV a complete selftest takes approx. 12 seconds.

The complete selftest *TST? consists of 10 different test routines for the individual hardware components, see `"DIAGnostic:SELFtest ..."`

In case of errors during the selftest, each error message is entered in plain text into the error queue. The error queue may be read out via the `SYST:ERR?` command.

During the selftest bit 9 in the STATus:OPERation register is set.

Example: `*TST?`

***WAI**

WAIT TO CONTINUE stops the remote control channel until all previous commands are executed. Thus controller and device can be easily synchronized. See also *OPC.

Example: `*WAI`

BERT – Bit Error Rate Tests

AMIQ is able to carry out BER tests **with a clock rate of approx. 100 Hz to 20 MHz.** All pertaining functions are controlled in this subsystem.

The BER test is performed by means of option AMIQ-B1. This option is simply installed by entering a key code (see command `SYST:OPT AMIQB1,xxxxxx`). For the measurement principle and further detailed information on the BER test refer to chapter 4.

To perform a BER test, a data signal and a corresponding clock signal is provided by the DUT. The polarity of both signals can be arbitrarily programmed in the AMIQ (commands `:BERT:SETup:CLOCk[:POLarity]`, `:BERT:SETup:DATA[:POLarity]`).

The signal provided by the DUT should correspond to a known (and adjustable) PRBS sequence (pseudo random bit sequence). The AMIQ compares this signal to the sequence generated by the internal PRBS generator. The type of PRBS generator to be used must be selected with the command `:BERT:SETup:TYPE` before the test is started.

The PRBS generator is then initialized with the data provided by the DUT. The AMIQ uses the first 24 bits after the beginning of the test and then activates the comparator and bit counter. All data received and all bit errors that occurred are counted. At the end of the test the ratio between the bit errors and the total number of data is calculated. This ratio is read out as the BER result.

Note: *If an error occurs during the first 24 bits, the internal PRBS generator will not be synchronized in the following and therefore detect a large number of bit errors. In this case, value no. 7 of `BERT:RESult?` is set to 0 indicating that the BER measurement is not synchronized and will be automatically repeated. Possible reasons for an excessive bit error rate are discussed in chapter 4, section "Possible Problems with BER Measurement and Related Solutions".*

The BER test is terminated if one of the following conditions is met:

- A given number of data is reached. This condition guarantees that the test is terminated after this number of data, however, if only few errors occurred, the BER result might still be inaccurate.
- A given number of bit errors is reached. This condition gives a quick result if the bit error rate is high. For a low bit error rate, the test takes longer but still has about the same accuracy.

  If the bit error rate is extremely small or zero, the test is terminated by the total number of data and not by the number of bit errors.
- The test is terminated by a remote control command.

Note: *None of the following commands is defined by the SCPI standard. The "Not SCPI" note in the command table was therefore omitted.*

For fast instrument setup for BER measurements see chapter 4, Signal Path and Waveform, PRBS data

Table 6-2 BERT – Bit error rate tests

Command	Parameter	Notes
:BERT:COPY	<name>	No query
:BERT:DELete	<name>	No query
:BERT:RESult?		Query only
:BERT:SELect	<name>	
:BERT:SETup:TYPE	PRBS9 | PRBS11 | PRBS15 | PRBS16 | PRBS20 | PRBS21 | PRBS23	
:BERT:SETup:CLOCk[:POLarity]	RISing | FALLing	
:BERT:SETup:DATA[:POLarity]	NORM | INVerted	
:BERT:SETup:MASK alias :BERT:SETup:DENable	OFF | HIGH | LOW	
:BERT:SETup:MCOunt	<n>	Range: 1 ... 4294967294
:BERT:SETup:MERRor	<n>	Range: 1 ... 4294967294
:BERT:SETup:RESTart	INTernal | EXTernal	
:BERT:STARt		
:BERT:STOP		

:BERT:COPY <name>

copies the specified BERT file from the floppy to drive C: of the AMIQ. It is not allowed to specify any drive names and paths; the default drive set via `MMEM:MSIS <drive>` is ignored. The BERT file is a file containing the configuration information for the (reprogrammable) hardware. If a file with the same name already exists, error message –282, "Illegal program name" is generated to avoid an inadvertent overwriting (if required delete before with `BERT:DEL`). If the file does not exist on the floppy, error message –256, "Filename not found" is generated. A query does not exist.

Example: `:BERT:COPY "NEW_BER"`

Note: *This function is not needed for usual operation, it is used only for retrofitting further BER options and for service purposes.*

:BERT:DELete <name>

clears the specified BERT file from drive C: of the AMIQ. It is not allowed to specify any drive names and paths; the default drive set via `MMEM:MSIS <drive>` is ignored. If the file does not exist on the floppy, error message –256, "Filename not found" is generated. A query does not exist.

Example: `:BERT:DEL "OLD_BER"`

Note: *This function is not needed for usual operation, it is used only for retrofitting further BER options and for service purposes.*

:BERT:RESult?

transfers the result of the last BER measurement to the host. The response to the query comprises 7 numeric values separated by commas.

Example: `:BERT:RES?`

Response: `"10000,5,5E-4,1,1,1,1"`

Value No.: `"1 ,2,3 ,4,5,6,7"`

Value No. 1	Number of data bits in the current query.	
Value No. 2	Number of error bits in the current query.	
Value No. 3	Bit error rate; if none of the stop conditions was reached since the start of the BER measurement, this value corresponds to the current ratio between "number of error bits" and "number of data bits". If at least one end result was obtained during the current (and still ongoing) measurement, the value corresponds to the last end result obtained. This keeps the BER indication more steady (over the time).	
Value No. 4	1	The BER measurement was terminated, i.e., the number of data bits or error bits specified by means of the commands "BERT:SET MCOunt <n>" or "BERT:SET MERRor <n>" was reached, or the BER measurement was stopped with the command "BERT:STOP".
	0:	The BER measurement is not yet terminated.
Value No. 5	1:	After the start of a BER measurement (by means of the command "BERT:STARt") an edge was detected on the clock line.
	0:	The clock line is not active
Value No. 6	1:	After the start of a BER measurement (by means of the command "BERT:STARt") a data change was detected on the data line. This data change relates to clocked data only; without a clock, no data changes are detected.
	0:	The data line is not active.
Value No. 7	1:	The BER measurement is synchronized, i.e., clock and data line are active and the ratio between "number of error bits" and "number of data bits" is better than 0.1 so that the measurement result obtained can be considered to be reasonable.
	0:	The BER measurement is not synchronized. For reasons refer to chapter 4, section "Possible Problems with BER Measurement and Related Solutions".

:BERT:SELect <name>

notes down the BERT file for programming the BERT-FPGA copied to drive C: via `BERT:COPY <name>`. It is not allowed to specify any drive names and paths; the default drive set via `MMEM:MSIS <drive>` is ignored. Programming is performed only when the device is switched on the next time. After changing the BERT file the instrument must be switched off and on again.

At present, the following BERT files exist:

NONE Contains no BER measurement, is used for service purposes and if the option is not installed.

PRBS Contains BER measurement using the PRBS method. The following commands can only be used if PRBS measurement is selected.

Example: `:BERT:SEL "PRBS"` *RST value: NONE

:BERT:SETup:...

Depending on the loaded BERT file (see `:BERT:SELect`) further settings can be made with the aid of the following commands:

:BERT:SETup:TYPE PRBS9 | PRBS11 | PRBS15 | PRBS16 | PRBS20 | PRBS21 | PRBS23

Various lengths of the pseudo random number sequence can be set for the BERT file "PRBS". The values "PRBS9" to "PRBS23" are only useful for this file. This command can be extended by other parameter values for the other BERT files. The PRBS polynomials corresponding to the parameters selected here are explained in chapter 4.

Example: `:BERT:SET:TYPE PRBS15` *RST value: PRBS9

:BERT:SETup:CLOCk[:POLarity] RISing | FALLing

determines the active edge of the externally applied clock signal. The clock signal is supplied to pin 6 of the BER-connector.

Example: `:BERT:SET:CLOC RIS` *RST value: RIS

:BERT:SETup:DATA[:POLarity] NORM | INVerted

determines the polarity of the external data signal. The data signal is supplied to pin 7 of the BER-connector.

NORM: High level corresponds to logic 1, low level to logic 0.

INV: Low level corresponds to logic 1, high level to logic 0.

Example: `:BERT:SET:DATA INV` *RST value: NORM

:BERT:SETup:DENable OFF|HIGH|LOW alias

:BERT:SETup:MASK OFF|HIGH|LOW

AMIQ is provided with an input (Data Enable) which permits the BER measurement to be temporarily disabled so that data bursts or data interrupted by other data can be processed. This command configures this input. The data enable signal is supplied to pin 8 of the BER connector.

OFF: A signal applied to input 8 is ignored, all data are used for BER measurement

HIGH: While input 8 is high, the data bits supplied are counted, bit errors are detected and counted as well. If the input is low, the measurement is interrupted.

LOW: While input 8 is low, the data bits supplied are counted, bit errors are detected and counted as well. If the input is high, the measurement is interrupted.

Example: `:BERT:SET:MASK HIGH` *RST value: OFF

Note: The requirements for the data enable input concerning setup and hold times are the same as for the data input.

:BERT:SETup:MCOunt <n>

This command sets the total number of data bits to be measured (data masked by the command `BERT:SETup:MASK` are not counted). As soon as the internal counter has reached this number (or exceeded this number, in case of the integrating BER test), the BER measurement is terminated. If the query `"BERT:RES?"` is sent to the AMIQ, the 4th value of the response indicates that the BER measurement has been terminated. This 4th value is set to 1.

Possible range: 1 ... 4294967294 (2^{32}-1)

Example: `:BERT:SET:MCO 10000` *RST value: 10000

:BERT:SETup:MERRor <n>

This command sets the number of error bits to be measured. As soon as the internal bit error counter has reached this number (or exceeded this number, in case of the integrating BER test), the BER measurement is terminated. If the query `"BERT:RES?"` is sent to the AMIQ, the 4th value of the response indicates that the BER measurement has been terminated. This 4th value is set to 1.

Possible range: 1 ... 4294967295 (2^{32}-1)

Example: `:BERT:SET:MERR 10` *RST value: 100

:BERT:SETup:RESTart INTernal|EXTernal

INT: The reset signal for the BER measurement is internally generated by the program. This setting is suitable for random sequences which cyclically fit into the memory of the AMIQ so that an uninterrupted repetition of the sequence is guaranteed.

EXT: If the random sequence during the memory cycle cannot be continued without interruption, the BER measurement must be stopped in time and re-started at the beginning of the data sequence. The halt and start is effected by means of a 0-1-0 transition at the input RES (pin 9 of D-sub connector). The BER results are added up until the predefined total number of data or error bits are attained or exceeded (integrating BER measurement).

For details on the two BER measurement methods see chapter 4, sections
"Measurement of Bit Error Rate"
"Test Method", in particular the paragraphs:
"BER measurement with uninterrupted repetition of the random sequence"
"BER measurement with interrupted random sequence- integrating BER measurement"

The restart signal for the BER test is generated internally by the program (INT) or by a 0-1-0 edge at pin 9 (RESTART) of the BER connector (EXT).

Example: `:BERT:SET:REST EXT` *RST value: INT

Attention: *If the restart signal is applied in time intervals shorter than the measurement time set, the measurement can not be terminated because it is restarted over and over again. Thus, no valid result can be obtained.*

:BERT:STARt

This command starts a BER measurement and sets the result to NAN (not a number).

Example: `:BERT:STAR`

:BERT:STOP

This command stops a running BER measurement. The command has no effect if there is no measurement.

Example: `:BERT:STOP`

CALibration – Adjustment and Calibration

This command set contains functions for automatic adjustment (which can be performed without any external facilities being required) and adjustment settings. All determined or set values are stored in the AMIQ-internal EEPROM or on the hard disk and transferred back to the hardware each time the instrument is switched on.

All functions return 0 after a successful execution, otherwise an error code unequal 0. Each unsuccessful calibration generates an entry in the error queue which can be queried with `:SYSTem:ERRor?`.

Note: *All offset and amplitude calibrations as well as `:CAL:ALL?` determine separate values for the filter settings OFF, 2.5 MHz, 25 MHz and EXT, irrespective of the value set for `:OUTP:I | Q:FILT`. If an external filter is not connected, the routines cannot determine calibration values for them. A respective warning is output in this case and a result unequal 0 is returned via remote control. The values for the other filter settings are correctly determined and stored. To avoid a warning being output, external filters have to be connected, in the simplest case a cable which connects the filter output to the pertaining filter input.*

While adjustment functions are executed, the I and Q outputs are switched off and various settings changed. After the execution is terminated, the previous device status is restored. This implies that the time required for the automatic adjustment is extended by the time needed to restore the previous device status depending on the length of the loaded curve. To keep this time as short as possible it is recommended to load a short curve (e.g. SINE.WV) before calling up the automatic adjustment.

Except for `:CALibration:ALL?` none of the commands is specified by the SCPI standards. "Not SCPI" was therefore omitted in the command table.

*RST is not effective for this command set. Since the instrument was adjusted in the factory, default settings cannot be specified.

Table 6-3 CALibration – Adjustment and calibration

Command	Parameter	Notes
:CALibration:ALL?		Query only
:CALibration:AMPLitude?		Query only
:CALibration:AMPLitude:VALue?		Query only
:CALibration:AMPLitude:I?		Query only
:CALibration:AMPLitude:I:VALue?		Query only
:CALibration:AMPLitude:Q?		Query only
:CALibration:AMPLitude:Q:VALue?		Query only
:CALibration:DIAGnose	0.9000 to 1.1000	
:CALibration:OFFSet?		Query only
:CALibration:OFFSet:VALue?		Query only
:CALibration:OFFSet:I?		Query only
:CALibration:OFFSet:I:VALue?		Query only
:CALibration:OFFSet:Q?		Query only
:CALibration:OFFSet:Q:VALue?		Query only
:CALibration:ROSCillator	0 to 4095	

:CALibration:ALL?

executes all automatic adjustments described below. If all of the operations are executed without an error, 0 is returned. A value unequal 0 is returned if at least one of the operations failed.

Example: `:CAL:ALL?`

:CALibration:AMPLitude?

adjusts the signal generation hardware for the operating modes :OUTP:I | Q VAR and FIX. For full-scale of the waveform D/A converter, the hardware is adjusted so that the amplitude at the I and Q output is exactly 1 V (EMF).

Example: `:CAL:AMPL?`

:CALibration:AMPLitude:VALue?

returns a list of the amplitude calibration values stored in the EEPROM in ASCII format, separated by commas. 18 values are returned:

I_Ampl_Adj[0...3], I_Ampl_Var_p2V, I_Ampl_Var_p90mV, I_Ampl_Var_0V, I_Ampl_Var_m90mV, I_Ampl_Var_m2V, Q_Ampl_Adj[0...3], Q_Ampl_Var_p2V, Q_Ampl_Var_p90mV, Q_Ampl_Var_0V, Q_Ampl_Var_m90mV, Q_Ampl_Var_m2V

Example: `:CAL:AMPL:VAL?`

:CALibration:AMPLitude:I?

adjusts the signal generation hardware for the operating modes :OUTP:I VAR and FIX. For a full-scale of the waveform D/A converter, the hardware is adjusted so that the amplitude at the I output is exactly 1 V (EMF).

Example: `:CAL:AMPL:I?`

:CALibration:AMPLitude:I:VALue?

returns a list of the amplitude calibration values stored in the EEPROM for channel I in ASCII format, separated by commas. 9 values are returned:

I_Ampl_Adj[0...3], I_Ampl_Var_p2V, I_Ampl_Var_p90mV, I_Ampl_Var_0V, I_Ampl_Var_m90mV, I_Ampl_Var_m2V

Example: `:CAL:AMPL:I:VAL?`

:CALibration:AMPLitude:Q?

adjusts the signal generation hardware for the operating modes :OUTP:Q VAR and FIX. For a full-scale of the waveform D/A converter, the hardware is adjusted so that the amplitude at the Q output is exactly 1 V (EMF).

Example: `:CAL:AMPL:Q?`

:CALibration:AMPLitude:Q:VALue?

returns a list of the amplitude calibration values stored in the EEPROM for channel Q in ASCII format, separated by commas. 9 values are returned:

Q_Ampl_Adj[0...3], Q_Ampl_Var_p2V, Q_Ampl_Var_p90mV, Q_Ampl_Var_0V, Q_Ampl_Var_m90mV, Q_Ampl_Var_m2V

Example: `:CAL:AMPL:Q:VAL?`

:CALibration:DIAGnose 0.9000 to 1.1000

specifies a calibration factor for the diagnostic A/D converter with the aid of which measurement errors of the converter can be compensated for. Each measured value is multiplied by this calibration factor before it is output. An external DC voltmeter is required for exact determination of this value. The procedure is described in the Service Manual.

Example: `:CAL:DIAG 1.04`

:CALibration:OFFSet?

adjusts the residual DC offset and the offset setting error at the I/ Q outputs to a minimum. Separate values are determined and stored for each filter setting value (see also the note at the beginning of this section).

Example: `:CAL:OFFS?`

:CALibration:OFFSet:VALue?

returns a list of the offset calibration values stored in the EEPROM in ASCII format, separated by commas. 58 values are returned:

I_Offset1_Adj_FIX[0 ... 3], I_Offset1_Adj_VAR[0 ... 3], I_Offset2_Adj[0 ... 20],
Q_Offset1_Adj_FIX[0 ... 3], Q_Offset1_Adj_VAR[0 ... 3], Q_Offset2_Adj[0 ... 20]

Example: `:CAL:OFFS:VAL?`

:CALibration:OFFSet:I?

adjusts the residual DC offset and the offset setting error at the I output to a minimum. Separate values are determined and stored for each filter setting value (see also the note at the beginning of this section).

Example: `:CAL:OFFS:I?`

:CALibration:OFFSet:I:VALue?

returns a list of the offset calibration values stored in the EEPROM for channel one in ASCII format, separated by commas. 29 values are returned

I_Offset1_Adj_FIX[0 ... 3], I_Offset1_Adj_VAR[0 ... 3], I_Offset2_Adj[0 ... 20]

Example: `:CAL:OFFS:I:VAL?`

:CALibration:OFFSet:Q?

adjusts the residual DC offset and the offset setting error at the Q output to a minimum. Separate values are determined and stored for each filter setting value (see also note at the beginning of this section).

Q_Offset1_Adj_FIX[0 ... 3], Q_Offset1_Adj_VAR[0 ... 3], Q_Offset2_Adj[0 ... 20]

Example: `:CAL:OFFS:Q?`

:CALibration:OFFSet:Q:VALue?

returns a list of offset calibration values stored in the EEPROM for the Q channel in ASCII format, separated by commas. 29 values are returned

Example: `:CAL:OFFS:Q:VAL?`

:CALibration:ROSCillator 0 to 4095

enters the tuning voltage for the internal 10 MHz reference oscillator. With the aid of an external frequency counter, the internal reference oscillator can thus be accurately adjusted to 10 MHz. This value is stored in the EEPROM. The query returns the value stored in the EEPROM.

Example: `:CAL:ROSC 2102`

DIAGnostic – Hardware Diagnosis

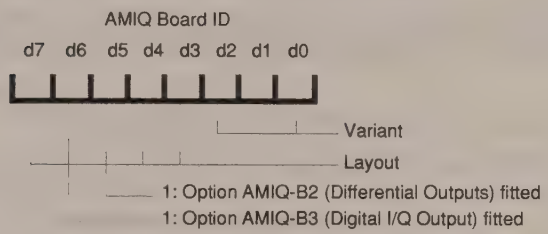
The commands of the diagnostic system inform on the internal device status.

Table 6-4 DIAGnostic – Hardware diagnosis

Command	Parameter	Notes
:DIAGnostic:ABOard:ID?		Query only; not SCPI
:DIAGnostic:TPOint<n>?		Query only; not SCPI

:DIAGnostic:ABOard:ID?

returns the ID of the built-in analog board.


AMIQ Board ID
d7 d6 d5 d4 d3 d2 d1 d0
Variant
Layout
1: Option AMIQ-B2 (Differential Outputs) fitted
1: Option AMIQ-B3 (Digital I/Q Output) fitted

AMIQ Board ID if no hardware option is fitted, i.e. if bits d_5 and d_6 are not set	AMIQ Model,	Response string upon *IDN?
145 (0x91)	02	"Rohde&Schwarz,**AMIQ**,..."
137 (0x89)	02	"Rohde&Schwarz,**AMIQ**,..."
153 (0x99)	02 or 03	"Rohde&Schwarz,**AMIQ02**,..." "Rohde&Schwarz,**AMIQ03**,..."
155 (0x9B)	04	"Rohde&Schwarz,**AMIQ04**,..."

Example: `:DIAG:ABO:ID?`

:DIAGnostic:TPOint<n>?

returns the voltage of the test point identified by <numeric_suffix> (permissible values: 0 to 15). The voltage is measured by means of the diagnostic A/D converter. To do so the desired test point is set, the converter started and after a waiting time of 60 ms (maximum duration of a conversion procedure) the result is returned. The test points are described in the service manual.

Example: `:DIAG:TPO7?`

:DIAGnostic:SELFtest:...?

A total of 11 selftest commands are available for testing individual components or programming a progress bar. The syntax and function of these command is listed in the following table.

Important note:

Before any of the selftest commands for individual components (`DIAG:SELF:BAS ... SDRam`) is executed it is absolutely necessary to save the current device status (`*SAV 'filename'`) and recall it after execution (`*RCL 'filename`) so that correct operation of AMIQ is guaranteed after the selftest. The device status for each of the components is not automatically restored in order to avoid the setup loading time which might be quite long depending on the length of the loaded curve. As in the case of a complete selftest, it is recommended to load a short curve before executing the `*SAV` command. This will keep the time for restoring the previous device state short.

Attention:

The execution time for the SDRAM test is approx. 30 seconds for AMIQ 03 (4,000,000 samples) and approx. 2 minutes for AMIQ 04 (16,000,000 samples). Please provide sufficient timeout in the controller.

On calling up the individual selftest components all errors are entered in the error queue.

The individual selftest components yield the ASCII result „0" if no error is detected, „1" in case of an error.

IEEE-Bus Command	Description

`*TST?`	The complete selftest consists of the 10 individual components described in the following:
	`DIAGnostic:SELFtest:BAS?`
	`DIAGnostic:SELFtest:DSYStem?`
	`DIAGnostic:SELFtest:DACReference?`
	`DIAGnostic:SELFtest:OADJust?`
	`DIAGnostic:SELFtest:OFFSet?`
	`DIAGnostic:SELFtest:REFFrequency?`
	`DIAGnostic:SELFtest:VCO?`
	`DIAGnostic:SELFtest:LEVels?`
	`DIAGnostic:SELFtest:ATTenuators?`
	`DIAGnostic:SELFtest:LPASs?`
	They are executed without interruption.
	`DIAGnostic:SELFtest:SDRam?`
	The selftest for the AMIQ's SDRAM is not included in `*TST?` because its execution time amounts to approx. 30 seconds for AMIQ 03 (4,000,000 samples) and approx. 2 min for AMIQ 04 (16,000,000 samples).
	The selftest yields the ASCII result „0" if no error is detected in any of the components, „1" in case of an error.

`DIAGnostic:SELFtest:BASics?` `DIAGnostic:SELFtest1?`	Sequencer FPGA file BER FPGA file Stock number of analog board EEPROM data
`DIAGnostic:SELFtest:DSYStem?` `DIAGnostic:SELFtest2?`	Zero point of the system Reference level of diagnostic AD-converter
`DIAGnostic:SELFtest:DACReference?` `DIAGnostic:SELFtest3?`	Reference level of all setting DACs
`DIAGnostic:SELFtest:OADJust?` `DIAGnostic:SELFtest4?`	Offset settings
`DIAGnostic:SELFtest:OFFSet?` `DIAGnostic:SELFtest5?`	Offsets in the signal path
`DIAGnostic:SELFtest:REFFrequency?` `DIAGnostic:SELFtest6?`	Clock frequency sources

IEEE-Bus Command	Description
DIAGnostic:SELFtest:VCO? DIAGnostic:SELFtest7?	VCO control voltage
DIAGnostic:SELFtest:LEVels? DIAGnostic:SELFtest8?	Operating level
DIAGnostic:SELFtest:ATTenuators? DIAGnostic:SELFtest9?	Attenuator test in the I and Q channel
DIAGnostic:SELFtest:LPASs? DIAGnostic:SELFtest10?	Identical filters in I and Q channels
DIAGnostic:SELFtest:SDRam? DIAGnostic:SELFtest11?	Test of SDRAM of AMIQ by means of a random binary sequence. ***Note:*** *The execution time for this command is approx 30 seconds for AMIQ 03 (4,000,000 samples) and approx. 2 minutes for AMIQ 04 (16,000,000 samples). Provide sufficient timeout in the controller.*

Example:
```
*SAV 'TEMP'
:DIAG:SELF:ATT?
*RCL 'TEMP'
```

Program example:

Selftest with progress indication
in the programming language C combined with the IEEE-bus driver GPIB.COM by National Instruments, see chapter 7!

MARKer – Marker Management

Two binary marker outputs are available for each channel. The status of the outputs is stored in the two least-significant bits of each waveform sample with the following assignment:

Marker output	Channel	Bit
Marker 1	I	Least-significant bit
Marker 2	I	Second bit
Marker 3	Q	Least-significant bit
Marker 4	Q	Second bit

A 1 in one of these bits generates high level at the associated marker output, 0 the corresponding low level.

The marker outputs can be programmed in three different ways:

- When the waveform file is generated with the host computer, the respective bits of each sample are set to the desired values.
- The markers are specified within the waveform file with the aid of the MARKER LIST tag.
- The markers are specified with the remote control command `:MARK:LIST <marker list>` independent of the waveform file.

In the case of a conflict between the marker values from a waveform loaded via the commands `MMEM:LOAD RAM,<filename>` or `MEM:DATA RAM,<Binärblock>` (and included in the data bits d0 and d1), and the marker values from a marker list loaded **afterwards** via the command `MARK<n>[:LIST] <marker list>`, the markers from the list have the priority.

If the marker values of a marker list do not correspond (eg `MARK1 '100-101:0;100-101:1'`), the last setting is valid.

When a waveform is loaded via the commands `MMEM:LOAD RAM, 'filename>` or `MEM:DATA RAM;<Binärblock>`, the existing marker lists are deleted (an empty marker list "0-0:0" is generated) so that the marker bits included in the waveform can become effective.

Note: *The :MARKer subsystem is available four times (:MARKer1 to :MARKer4) for the four marker channels. Markers 1 and 2 belong to the I channel, markers 3 and 4 to the Q channel.*

If the "Rear I/Q Outputs" option (AMIQ-B19) is installed, marker outputs 3 and 4 on the rear are not available because they are used for the I and Q output signals, i.e. the I output is assigned to marker output 4 and the Q output to marker output 3.!
If "Digital I/Q Output" option (AMIQ-B3) is ***not installed****, any commands relating to these marker outputs are ineffective, but no error message is output.*
If the option is installed, marker outputs 3 and 4 are available on data lines Q0 and Q1 (see chapter 4, "Digital I/Q Output" option AMIQ-B3).

Table 6-5 MARKer – Marker management

Command	Parameter	Notes
:MARKer<n>[:LIST]	<marker list>	Not SCPI

:MARKer<n>[:LIST] <marker list>

transfers a marker list to AMIQ. The markers are immediately stored in the RAM (an ongoing output is interrupted and has to be restarted). The markers of the waveform currently in the RAM are changed. The waveform file on the hard disk is not affected, but can be changed with the aid of an update waveform file (see section "Waveform File Format" {TYPE:WV-ADD}).

Since marker lists are saved in the AMIQ's setup same as any other command, they must not be greater than 450 character long in order not to overburden the setup files. This has the benefit that marker lists up to this length are immediately set following the power-off/on of the AMIQ or after loading a setup with `*RCL <name>`.

Longer marker lists should be split and transferred by means of several commands. After power-off/on of AMIQ or loading a setup only the last part of the marker list is available. This means that longer marker lists should be transferred directly to the required trace using the WinIQSIM software.

The query `MARK<n>?` returns the marker list of the waveform currently in the RAM. The list contains any number of entries separated by colons, which may have one of the following forms:

start-end:value or **start:value**

with **start**: start index
end: end index; exclusive, ie the markers of samples with this index are not changed
value: **0** or **1**

start-end:value: Specification of marker ranges
‚value' applies in the range between the specified start index and end index. The markers in ranges not specified remain unchanged.

start:value: Specification of marker changes
‚value' applies in the range between the specified start index and the next specified start index or up to the end of the waveform. The markers in all ranges are changed.

The list may contain any number of marker changes or ranges. **Start** must of course be lower than the length of the loaded waveform. **Start** and **value** are ASCII coded, *not* in binary form.

AMIQ has a delay line (in the form of software) for each marker channel, which can be set in the :OUTPut subsystem.

Example: `MARK1 "0-100:1;200-400:0"` *RST value: 0-0:0 empty list

After the output has been started, high level is present at the marker 1 output during the output of samples 0 to 100. From sample 101 to 199, the level depends on the value of the least-significant bits of the samples (because no entries have been made for this in the marker list). From sample 200 to 400 the output is at high level. From sample 401 till the end of the waveform the level again depends on the values in the samples.

If a trace with a generation resolution of 16 bits is loaded (see trace file format {RESOLUTION 16,x} in this chapter), the marker list command is ineffective. However there will be no error message because the dependence between the generation resolution of a trace and the marker outputs is already taken into account in WinIQSIM.

The marker lists can be called up again after loading a trace with a generation resolution of 14 bits.

MEMory/MMEMory – Waveform Management

AMIQ is able to store waveform files on its internal hard disk from where they are loaded in the output buffer. The commands of the two systems allow waveform files to be transferred between controller and AMIQ and the management (copying, shifting, renaming, clearing) of waveform files and directories on the AMIQ hard disk.

The command for a direct transfer of waveform data from the IEC/IEEE bus to the RAM is part of the MEMory subsystem. According to SCPI, all commands for accessing the hard disk and the floppy are contained in the MMEMory system. Because of the similarity of the functions, the two systems are dealt with in one section.

The MMEMory subsystem manages only waveform files. Executable batch files are managed in the :PROGram subsystem.

Note: *Although the functions (copying, clearing, changing directory, etc) are similar to those of DOS, SCPI keywords and parameters are often different from the familiar DOS conventions. For reasons of SCPI compatibility, AMIQ uses SCPI forms as far as possible. A few alternative commands (eg CD for CDIRectory, MD for MDIRectory, and RD for RDIRectory) were introduced for the sake of compatibility with DOS conventions.*

AMIQ provides a virtual file system on its hard disk with the drives C:, D:, E:, and F: (D:, E:, and F: are logical partitions on the hard disk). The drives can be defined as default drives via the command `MMEMory:MSIS <drive>`.

Note: *The AMIQ has **at least** the two drives **C: and D:** with a storage capacity of 2000 Mbyte on drive C: and the rest on drive D:, depending on the installed disk drive. It may also have other drives.*
Which and how many drives AMIQ actually has depends on the supply of disk drives at the time and can be found out by means of commands `MMEMory:SCATalog?` and `MMEMory:SCATalog:LENGth?`

Each drive has only one directory level. All path names for the drives are relative to a fictitious root directory to be addressed with \. The specified names are not the DOS file names. There are no restrictions for file operations on the floppies.

With all data transfer commands, the data for the **two** channels are transferred simultaneously.

Table 6-6 MEMory – Waveform management

Command	Parameter	Notes
:MEMory:DATA	RAM, <binary block data>	
:MEMory:NAME?		Query only; not SCPI

Table 6-7 MMEMory – Waveform management

Command	Parameter	Notes
:MMEMory:CATalog | DIRectory?		Query only
:MMEMory:CATalog:LENGth?		Query only; not SCPI
:MMEMory:CDIRectory | CD	<directory>	
:MMEMory:COPY	<filename> [, <dest>]	
:MMEMory:DATA	<filename>, <bin. block data> *	no query
:MMEMory.DATA?	<filename>[,<tag>] *	
:MMEMory:DATA:LENGth?	<filename> [,<tag>] *	not SCPI

Command	Parameter	Notes
:MMEMory:DCATalog | DDIRectory?		Query only; not SCPI
:MMEMory:DCATalog | DDIRectory:LENGth?		Query only; not SCPI
:MMEMory:DELete	<filename> *	
:MMEMory:LOAD	RAM, <filename> *	
:MMEMory:MDIRectory | MD	<directory>	nicht SCPI
:MMEMory:MSIS	<drive>	
:MMEMory:RDIRectory | RD	<directory>	nicht SCPI
:MMEMory:SCATalog?		nicht SCPI
:MMEMory:SCATalog:LENGth?		nicht SCPI

* compose <filename>

Trace file names can be given in different ways for commands marked with *:

- If **only the trace file name is given** in <filename> (neither drive not path), then <filename> refers to the default drive selected with `MMEM:MSIS <drive>` and the default directory set with `MMEM:CD <directory>`.

  Example:
  ```
  :MMEM:MSIS 'D:'
  :MMEM:CD 'MYDIR'
  :MMEM:LOAD RAM, 'MYWAV'
  ```
  accesses D:\MYDIR\MYWAV.WV'.

- If **a path with a trace file name** is given in <filename>, then <filename> refers to the default drive selected with `MMEM:MSIS <drive>`.

  Example:
  ```
  :MMEM:MSIS 'D:'
  :MMEM:LOAD RAM, '\MYDIR\MYWAV'
  ```
  accesses D:\MYDIR\MYWAV.WV'

- If **drive and trace file name** is given <filename>, then the specified drive is linked with the default directory set by means of `MMEM:CD <directory>`.

  Example:
  ```
  :MMEM:CD 'MYDIR'
  :MMEM:LOAD RAM,'D:MYWAV'
  ```
  accesses D:\MYDIR\MYWAV.WV'

- If **drive, path and file name** but no path is given in <filename>, then access is made irrespective of the default drive and default path.

  Example:
  ```
  :MMEM:LOAD RAM, 'D:\MYDIR\MYWAV'
  ```
  accesses D:\MYDIR\MYWAV.WV'

:MEMory ...

This command system contains the command for the transfer of trace data from the IEC/IEEE bus into the RAM of AMIQ.

:MEMory:DATA RAM, <binary block data>

The command takes the waveform file (in binary block data format) from the IEC/IEEE bus and directly stores it in the RAM. Note that RAM is *not* specified in inverted commas. Any curve in the RAM is overwritten.

Attention: *A curve loaded directly into AMIQ's SDRAM by means of this command (e.g. using WinIQSIM and the settings **Transmission**, **Force internal**, **Destination AMIQ-RAM**) is no longer available after AMIQ is switched off and on again. The ON LED blinks.*

The lowest two bits of each sample set the marker outputs (see comments in the description of the :MARKer system) but do not influence the analog value at the I/Q outputs. A `:MARKer:LIST`-command overwrites these bits.

This command clears all existing marker lists (generating empty marker lists "0-0:0") so that any marker bits included in the waveform can become effective.

Example:

Transferring a waveform file as a binary block from the process controller to the AMIQ output RAM via the IEC/IEEE bus:

`MMEMory:DATA RAM,` `#3767` <binary data>

- 767 bytes of curve form
- Length in ASCII of binary data record bytes
- Number of digits of subsequent length information in ASCII
- # The ASCII Character # initiates binary block transfer

<Binary data> designates a data block structured like the contents of a waveform file, i.e. comprising at least the {TYPE} tag and the {WAVEFORM} tag, e.g.
{TYPE: WV, 0}{WAVEFORM-403: 0,#IIQQIIQQIIQQ.....IIQQ}

:MEMory:DATA? RAM[,<tag>]

The query form of the MEMory:DATA command transmits the following of the waveform in the RAM
- the whole contents of the waveform if no tag name is given, (eg `MEM:DATA?`)
- the contents of the tag if a tag name is indicated (eg `MEM:DATA? RAM,'COMMENT'`)

in the binary block format from AMIQ to the controller.
If the trace is encoded (generated with WinIQSIM) re-reading of the waveform data is refused with error message "261, Waveform protected".
For a definition of tags see section "Waveform File" on page 6.54 ff. For handling of file names see section "*compose <filename>" on page 6.23.

Example:

The COMMENT tag of the trace in the RAM is

{COMMENT: I = cosine, Q = sine, 100 points, 100 kHz at clock 10 MHz; Marker 1 set for 10 samples (=1µs)}

With the command

```
MMEMory:DATA? RAM,'COMMENT'
```

the content of the tag of the trace in the RAM is returned.

Reply: `#293 I = cosine, Q = sine, 100 points, 100 kHz at clock 10 MHz; Marker 1 set for 10 samples (=1µs)`

:MEMory:NAME?

returns the name of the waveform file in the output buffer.

Example: `:MEM:NAME?`

Response (example): `"C:\DUALTONE.WV"`
`"RAM"` if the curve was directly loaded into the RAM via MEM:DATA RAM, <binary block data>

:MMEMory ...

This command system contains all the commands for accessing the hard disk and diskette.

:MMEMory:CATalog | DIRectory?

returns a list of the waveform files in the default drive (`MMEM:MSIS <drive>`) and default directory (`MMEM:CD <directory>`). The list is in the following format (without the line breaks):

```
<used_bytes_in_this_directory>,<free_bytes_on_this_disk>,
"name1,TRAC,<filesize_in_bytes>",
"name2,TRAC,<filesize_in_bytes>",
"name3,TRAC,<filesize_in_bytes>", ...
```

Example:

```
:MMEM:MSIS 'D:'      Set default drive D:
:MMEM:CD 'MYDIR'     Set default drive MYDIR
:MMEM:CAT?           Call waveform file
```

If drive A: is specified with a directory or path by means of `MMEM:CD <directory>`, then the drive set with `MMEM:MSIS <drive>` is ignored and all trace files on the diskette under the given directory is listed.

Example:

```
:MMEM:CD 'A:\ADIR1'
:MMEM:CAT?
:MMEM:CD 'A:\ADIR1\ADIR2'
:MMEM:CAT?
```

:MMEMory:CATalog:LENGth?

returns the number of waveform files in the default drive (`MMEM:MSIS <drive>`) and default directory (`MMEM:CD <directory>`). This is equal to the number of entries in the list generated by `MMEMory:CATalog?`

Example: `:MMEM:CAT:LENG?`

:MMEMory:CDIRectory | CD <directory>

changes the default directory. <directory> is the path relative to the waveform root directory of one of the AMIQ drives or the path on the floppy. The command `MMEMory:MSIS <drive>` defines the default directory (C:, D:, E:, or F:). A directory on one of the drives must not contain any subdirectories (ie no backslashes). For a directory on floppy, drive and path can be specified. The waveform root directory can be addressed with \ and used like any other waveform directory.

Note: The effect of this command slightly differs from the corresponding DOS command. The set default directory is only used when a file name is entered **without** a path for a command that contains a file name as a parameter. If a file name is entered with a path, the path parameter refers to the virtual root directory and not to the default directory.

In response to `:MMEM:CDIR?` the name of the currently used directory is returned.

Example: `:MMEM:CDIR "winiqsim"` *RST value: "\"

Create the directory SUBDIR in drive D: and turn it into the default directory:

```
:MMEM:MSIS 'D:'
:MMEM:MDIR 'SUBDIR'
:MMEM:CDIR 'SUBDIR'
```

Change into a waveform directory on the floppy disk:

```
:MMEM:CDIR "A:" or "A:\"
:MMEM:CDIR "A:\DIR" or "A:\DIR\"
:MMEM:CDIR "A:\DIR\SUBDIR" or "A:\DIR\SUBDIR\" etc.
```

:MMEMory:COPY <filename> [, <destination>]

copies waveform files (characterized by the extension *.wv) from <filename> to <dest> on the AMIQ hard disk.

If no extension is specified, the specified file is interpreted as a waveform file. If no drive and no directory structure are specified, the file designated by <filename> is searched on the default drive (`MMEM:MSIS <drive>`) and in the default directory (`MMEM:CD <directory>`).

Examples:

```
:MMEM:MSIS 'D:'          Default settings for the ...
:MMEM:CD '\'             ... following three commands
:MMEM:COPY 'SWAVE.WV','DWAVE.WV'
```
Copy file in the default drive D: and within the waveform root directory with another name

```
:MMEM:COPY 'SWAVE','DWAVE'
```
Copy file in the default drive D: and within the waveform root directory with another name

```
:MMEM:COPY 'SWAVE','\SUBDIR\DWAVE'
```
Copy file in the default drive D: from the waveform root directory to a waveform subdirectory in the default drive D: with another name

If <dest> is not specified <filename> is copied to the default drive or to the default directory. Files on the hard disk having the same file name <dest> are overwritten without a warning.

Example:

```
:MMEM:MSIS 'D:'
:MMEM:CD 'MYDIR'
:MMEM:COPY '\DIR\WAVE.WV'
```
Copy on the default drive D: from the trace subdirectory DIR to the default directory MYDIR of the same name WAVE.WV

There are two ways of **copying between drives**:

1. Specifying drive, path and filename:

Example:

```
:MMEM:COPY 'C:\SUBDIR1\MY.WV','D:\SUBDIR1\MY.WV' or
:MMEM:COPY 'C:\SUBDIR1\MY.WV','D:\SUBDIR1'.
```

Copy drive C: to D: with specified path

```
:MMEM:MSIS 'D:'
:MMEM:CD 'MYDIR'
:MMEM:COPY 'A:SWAVE','DWAVE'
```

Copy from the root directory of the diskette to the default drive D: and the trace subdirectory MYDIR under another name

```
:MMEM:MSIS 'D:'
:MMEM:CD 'MYDIR'
:MMEM:COPY 'A:\SUBDIR\SWAVE',' ...
```

Copy from the trace subdirectory of the diskette to the default drive D: and its trace subdirectory under another name

```
:MMEM:COPY 'A:\SUBDIR\SWAVE',' ... DWAVE'
```

Copy from the trace subdirectory of the diskette to a trace subdirectory on drive C: under another name

```
:MMEM:COPY 'C:\SWAVE.WV','A:'
```

Copy from the root directory of drive C: to the root directory of the diskette provided the trace was not generated by WinIQSIM and is thus disguised.

2. Specifying drive and filenames only:

If copying should be made for example from directory MYDIR on drive C: to drive D: in a directory of the same name (therefore the same directory for both drives) the path MYDIR can be chosen as the default directory. The path then need not be given in <filename> ('\' not used).

Example:

```
MMEM:CD 'MYDIR'
MMEM:COPY 'C:MYWAV_C','D:MAW...
```

The copy of C:\MYDIR\MYWAV_C.WV → D:\MYDIR\MYWAV_D.WV runs analogously:

The MMEM:COPY command does not have a query form

:MMEMory:DATA <filename>, <binary block data>

This command transfers a waveform as a binary block from the process controller to AMIQ via the IEC/IEEE bus and stores it under <filename> in the selected directory on the AMIQ hard disk. Up to 500 waveform files can be stored in one directory - if this limit is exceeded, an error message is generated and the command is not executed. The query MMEM:DATA? <filename> transfers the waveform back to the PC if the curve was not created with WinIQSIM, and is scrambled therefore.

See section **"*compose <filename>"** on page 6 23 ff

Example:

Transferring a waveform file as a binary block from the process controller to AMIQ via the IEC/IEEE bus and storing it as a waveform file in AMIQ:

```
MMEMory:DATA 'MYCURVE.WV', #3767<binary data>
                            |||  767 bytes of curve form
                            ||  Length in ASCII of binary data record bytes
                            |  Number of digits of subsequent length information in ASCII
                            # The ASCII Character # initiates binary block transfer
```

<Binary data> designates a data block structured like the contents of a waveform file, i.e. comprising at least the {TYPE} tag and the {WAVEFORM} tag, e.g.
{TYPE: WV, 0}{WAVEFORM-403: 0,#IIQQIIQQIIQQ.....IIQQ}

Use the query form of the command to transfer a waveform file as a binary block from the AMIQ to the controller via IEC/IEEE bus interface.

```
MMEMory:DATA? 'MYCURVE.WV'
```

Response: `#3767`<767 bytes of curve>

:MMEMory:DATA? <filename>[, <tag>]

The query form of the MMEMory:DATA command transmits the following of the waveform file indicated with `<filename>`

- the whole contents of the waveform if no tag name is given
- the contents of the tag if a tag name is indicated

in binary format from AMIQ to the controller.
If the waveform file indicated with `<filename>` is encoded (generated with WinIQSIM) re-reading of waveform data is refused with error message "261, Waveform protected" .

For a definition of the tags refer to section *Waveform File Format* on page 6.54. The handling of file names is explained in section "***compose <filename>**" on page 6.23.

Example:

The COMMENT tag in the waveform file SINE.WV reads:

{COMMENT: I = cosine, Q = sine, 100 points, 100 kHz at clock 10 MHz; Marker 1 set for 10 samples (=1µs)}

With the command

```
MMEMory:DATA? 'SINE.WV','COMMENT'
```

the contents of the tag are returned:

Response: `#293 I = cosine, Q = sine, 100 points, 100 kHz at clock 10 MHz; Marker 1 set for 10 samples (=1µs)`

:MMEMory:DATA:LENGth? <filename> [,<tag>]

This query command returns the length in byte of the waveform file <filename>. This does not include the SCPI block data header added at the beginning of the actual waveform file by the :MMEM:DATA? <filename> query. The file length returned is thus equal to the actual file length that would be returned, e.g., by the MS-DOS command DIR.

If the name of a tag is specified as a second parameter, the query returns the length of this tag including the tag header and the curved brackets. If the tag doesn't exist, 0 is returned. The handling of file names is explained in section "***compose <filename>**" on page 6.23.

Example:

Length of waveform file SINE.WV:

```
:MMEM:DATA:LENG? "sine.wv"
```

Response: `767` (File length of the waveform file SINE.WV)

Length of "WAVEFORM" tag (= count of waveform data) in waveform file SINW.WV:

```
:MMEM:DATA:LENG? "sine.wv", "WAVEFORM"
```

Response: `419` (Length of tag, including curved brackets)

```
{WAVEFORM-403: 0,#<400 I/Q values in binary data format>}
└──────────────── 419 ────────────────┘
```

Length of "COMMENT" tag in waveform file DUALTONE.WV:

```
:MMEM:DATA:LENG? "DUALTONE", "COMMENT"
```

Response: `68` (Length of tag, including curved brackets)

```
{COMMENT: Dual tone, 128 points, 0.9 MHz, 1.1 MHz at clock 12.8 MHz}
└──────────────────────────── 68 ────────────────────────────┘
```

:MMEMory:DCATalog | DDIRectory?

returns a list of waveform file directories of the default directory (`MMEM:MSIS <drive>`) separated by commas. This includes the backslash \ as the virtual root directory of the waveform file management.

It is not possible to generate a directory list of a floppy disk because the disk may contain a directory tree with an arbitrary number of sub-levels. The setting `MMEM:CD 'A:\'` is ignored – instead, the directory list of the drive preset via `MMEM:MSIS <drive>` is returned.

Example:
```
:MMEM:MSIS 'C:'
:MMEM:DCAT?
```

Response (for example): `"\","MYDIR","WINIQSIM"`

:MMEMory:DCATalog | DDIRectory:LENGth?

returns the number of waveform directories of the default drive Laufwerkes (`MMEM:MSIS <drive>`) below the virtual root directory. The number corresponds to the number of entries in the list generated by `MMEMory:DCATalog?`.

Example: `:MMEM:DCAT:LENG?`

:MMEMory:DELete <filename>

clears a file from the current directory. Drive and path can be specified. The file extension is always .wv. The handling of file names is explained in section "***compose <filename>**" on page 6.23.

Example:
```
:MMEM:DEL "mywave.wv"
:MMEM:DEL "winiqsim\mywave.wv"
:MMEM:DEL "\winiqsim\mywave"
:MMEM:DEL "A:\mywave.wv"
:MMEM:DEL "A:\mydir\mywave"
```

:MMEMory:LOAD RAM, <filename>

loads a file into the RAM. The keyword RAM must always be specified.

RAM and NONE are not allowed as file names !

The handling of file names is explained in section "***compose <filename>**" on page 6.23.

This command clears all existing marker lists (generates empty marker lists "0-0:0") so that all marker bits included in the waveform that may exist can become effective.

Examples:
```
:MMEM:LOAD RAM, "mywave"
:MMEM:LOAD RAM, "\winiqsim\mywave.wv"
:MMEM:LOAD RAM, "C:\mywave.wv"
:MMEM:LOAD RAM, "D:\mywave.wv"
:MMEM:LOAD RAM, "D:\winiqsim\mywave.wv"
```

Important note: *The AMIQ is delivered with a library of example waveforms preinstalled on the AMIQ hard disk. The waveform library contains of about 200 MBytes of examples covering the fields of multi carrier CW signals (directory \CW), GSM (directory \GSM), NADC (directory \NADC), W-CDMA (directory \WCDMA) and IS-95 CDMA (directory \CDMA). The directory \APPL_MAN contains the example waveforms described in the WinIQSIM Application Manual.*

Description of example waveforms see ***Chapter 7.***

If the trigger system is set to continuous data output (TRIG:MODE CONT), the output signal will appear at the I/Q outputs immediately after a curve has been loaded.

The `:MMEM:LOAD?` query returns the name of the file currently stored in the RAM; the response is identical with the response to the `:MEM:NAME` query.

Query: `:MMEM:NAME` or `:MMEMory:NAME?`

Reply eg: `C:\winiqsim\mywave.wv` or

`RAM` if a waveform was directly loaded into the AMIQ output RAM with the command MEM DATA RAM,<binaryblock>

:MMEMory:MDIRectory | MD <directory>

generates a new directory in the default directory (MMEM:MSIS <drive>). <directory> is the path relative to the waveform root directory on drives C:, D:, E:, or F: or the path on the floppy. A drive name included in <directory> (e.g. C:\MYDIR) is not allowed and will be ignored. The directory (e.g. C:**MYDIR**) is created in the default drive. A directory on one of the four default drives must not contain any further directory levels (ie no backslashes). Only one directory level is permissible under the waveform root directory. Up to 100 directories can be stored - above this number an error message is generated and the command is not executed.

For a directory on floppy, the drive name A: and a path can be specified. Creating directories on the disk corresponds largely to the function of the DOS command MD.

Example: :MMEM:MSIS 'C:'
:MMEM:MD "winiqsim" or :MMEM:MD "\winiqsim"
:MMEM:MD "winiqsim\subdir" **not allowed!**

Create a waveform directory on floppy disk:

:MMEM:MD "A:\MYDIR"
:MMEM:MD "A:\MYDIR\MYSUBDIR"

Observe order: Before MYSUBDIR can be created, MYDIR must be created.

:MMEMory:MSIS <drive>

MSIS = **M**ass **S**torage **I**dentification **S**tring.

This command selects the default hard disk drive with <drive> = 'C:', 'D:', 'E:' or 'F:' ('c:', 'd:', 'e:' or 'f:' are also permissible) and acts like the command C:, D:, E: or F: under DOS.

AMIQ offers at least drives C: and D: with a memory capacity of 2000 Mbyte in C: and the rest in D:, depending on the built-in hard disk drive; there may be more drives installed.
The type and number of hard disk drives installed in AMIQ depends on the current delivery situation for such drives. To check the drives installed, use commands MMEMory:SCATalog? and MMEMory:SCATalog:LENGth?.

If neither drives nor directories are specified in the trace file command (eg MMEM:LOAD RAM,'mywave.wv'), the trace file is searched for in the default drive and in the default directory set with MMEM:CD <directory>. The specified directory names (eg MMEM:MD 'mydir') always refer to the default drive.

The default drive refers to the handling command of trace files and their directories but not to the command systems BERT, PROGram and SYStem including *SAV and *RCL. Hard-disk access is solely for drive C: irrespective of the set default drive. The query (MMEM:MSIS?) returns the set default drive in plain text, eg D:.

Example: :MMEM:MSIS 'D:' or :MMEM:MSIS 'd:' *RST value: C:

:MMEMory:RDIRectory | RD <directory>

The command deletes the specified directory on the default drive (`MMEM:MSIS <drive>`). Naming a drive in <directory> (eg **C:**\MYDIR) is not permitted and will be ignored. Yet directory (eg C:**MYDIR**) is used and deleted on the default drive. The default directory and root directory "\" cannot be deleted.

The directory to be deleted for the diskette may contain the drive designation and path information and corresponds largely to the function of the DOS command RD.

Example:
```
:MMEM:MSIS 'C:'
:MMEM:RD "winiqsim"
```

To delete a trace directory on the diskette

```
:MMEM:RD 'A:\ADIR1\ADIR2'      deletes only ADIR2
:MMEM:RD 'A:\ADIR1             deletes  ADIR1
```

Note sequence: prior to being able to delete ADIR1, ADIR2 must be deleted.

:MMEMory:SCATalog?

(**S** of **S**CATalog stands for **S**torage and refers to the **S** of MS**I**S)
The command returns a list of drives available in AMIQ separated by commas.

Example: `:MMEM:SCAT?`

Reply eg: `"C:","D:"`

:MMEMory:SCATalog:LENGth?

The command returns the number of drives available in AMIQ.

Example: `:MMEM:SCAT:LENG?`

Reply eg `2`

OUTPut – Hardware Settings

The commands of this system determine characteristics of the various output sockets.

Table 6-8 OUTPut – Hardware settings

Command	Parameter	Notes
:OUTPut:BIAS	-2.5 V ... 2.5 V	For option AMIQ-B2 (Differential Outputs) Not SCPI
:OUTPut:CLOCk	ON | OFF	Not SCPI
:OUTPut:DIGital	ON | OFF	For Option AMIQ-B3 (Digital I/Q Output). This option is available for AMIQ model 03 and 04. Not SCPI
:OUTPut:FILTer	OFF | 2.5 MHz | 25 MHz | EXTernal	
:OUTPut:I:AMPLitude:BALanced	0 V...4 V	For option AMIQ-B2 (Differential Outputs) Not SCPI
:OUTPut:I:AMPLitude[:UNBalanced]	0 V to 1 V	Not SCPI
:OUTPut:I:FILTer	OFF | 2.5 MHz | 25 MHz | EXTernal	Not SCPI
:OUTPut:I[:STATe]	OFF | FIXed | VARiable | INVerted	
:OUTPut:Q:AMPLitude:BALanced	0 V...4V	Für Option AMIQ-B2 (Differential Outputs) Not SCPI
:OUTPut:Q:AMPLitude[:UNBalanced]	0 V to 1 V	Not SCPI
:OUTPut:Q:FILTer	OFF | 2.5 MHz | 25 MHz | EXTernal	Not SCPI
:OUTPut:Q[:STATe]	OFF | FIXed | VARiable | INVerted	
:OUTPut:MARKer<n>[:STATe]	ON | OFF	
:OUTPut:MARKer<n>:DELay	<samples>	
:OUTPut:OIMPedance	R50 | HIGH	Not SCPI
:OUTPut:RESolution	8 ... 16	nicht SCPI
:OUTPut:TYPE	BALanced | UNBalanced	BALanced only for option AMIQ-B2 (Differential Outputs)

:OUTPut:CLOCk ON | OFF

through-connects (ON) the sampling clock of the waveform D/A converter to the clock output or switches it off (OFF).

Example: `:OUTP:CLOC ON` *RST value: ON

:OUTPut:DIGital ON | OFF

The command ON switches on the 16-bit wide digital I/Q outputs if pin 66 of the 68-contact SCSI connector is at HIGH. For details see chapter 4, section "Option Digital I/Q Output AMIQ-B3". For the ON setting to be effective, the digital I/Q output option (AMIQ-B3) must have been installed. The option is available for models 03 and 04 of AMIQ.

Example: `:OUTP:DIG ON` *RST value: OFF

:OUTPut:FILTer OFF | 2.5MHz | 25MHz | EXTernal

determines the reconstruction filters to be cut into the signal path. AMIQ comprises two internal lowpass filters of 2.5 MHz and 25 MHz and allows an external filter to be cut in or not to use any filter at all. The filters for the two channels can be switched separately or together in one command. The command affects both channels, with `:OUTP:I:FILT` or `:OUTP:Q:FILT` the channels can be separately switched and queried.

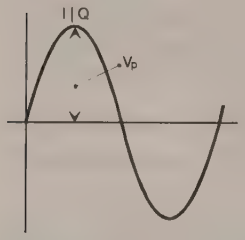
The query returns two values separated by a comma. The first value is for the I channel, the second for the Q channel.

Example: `:OUTP:FILT EXT` *RST value: OFF

:OUTPut:I:AMPLitude[:UNBalanced] 0V to 1V

sets the output level V_p for the asymmetric outputs. It is only effective when `OUTP:I VARiable` or `INVerted` is set. The parameter denotes the peak amplitude if the output is terminated in 50

If AMIQ is in the BALanced mode (option AMIQ-B2, Differential Outputs) this command acts as a preset command, i.e. the level is set on switching over to the UNBalanced mode.



Example: `:OUTP:I:AMPL 0.45V` *RST value: 1V

:OUTPut:I:FILTer OFF | 2.5MHz | 25MHz | EXTernal

determines the reconstruction filter to be cut into the signal path of the I channel. AMIQ is provided with two internal lowpass filters with limit frequencies of 2.5 MHz and 25 MHz, allows an external filter to be cut in or not to use any filter at all. The filters of the two channels can be switched separately or together in one command. This command is only effective for the I channel. With `:OUTP:FILT` both channels can be switched and queried.

Example: `:OUTP:FILT:I 25MHz` *RST value: OFF

:OUTPut:I[:STATe] OFF | FIXed | VARiable | INVerted

switches the I and Q outputs between fixed level (FIX, V_{pp} = 1 V into 50 Ohm), variable level (VAR), inverted variable level (INV) and off (OFF). In the OFF state, the OUTP:OIMP R50 | HIGH command determines the impedance of the outputs that are switched off. The level set for INV is identical to the level for VAR, however, the phase of the curve is shifted by 180 deg.

Example: `:OUTP:I VAR` *RST value: OFF

:OUTPut:Q:AMPLitude[:UNBalanced] 0V to 1V

sets the output level V_p for the asymmetric outputs. It is only effective when `OUTP:Q VARiable` or `INVerted` is set. The parameter denotes the peak amplitude if the output is terminated in 50

If AMIQ is in the BALanced mode (option AMIQ-B2, Differential Outputs) this command acts as a preset command, i.e. the level is set on switching over to the UNBalanced mode.

Example: `:OUTP:Q:AMPL 0.12V` *RST value: 1V

:OUTPut:Q:FILTer OFF | 2.5MHz | 25MHz | EXTernal

determines which reconstruction filter is cut into the signal path of the Q channel. AMIQ is provided with two internal lowpass filters with limit frequencies of 2.5 MHz and 25 MHz and allows an external filter to be cut in or not to use any filter at all. The filters can be switched separately or together in one command. This command is only effective for the Q channel. With `:OUTP:FILT` the channels can be switched and queried together.

Example: `:OUTP:Q:FILT 2.5MHz` *RST value: OFF

The `OUTP:FILT?` query **simultaneously** returns the filter in the I channel and in the Q channel.

Query: `:OUTP:FILT?`

Reply eg: `2.5MHZ, 25MHZ`

:OUTPut:Q[:STATe] OFF | FIXed | VARiable | INVerted

switches the Q output between fixed level (FIX, V_{pp} = 1 V an 50 Ohm), variable level (VAR), inverted variable level (INV) and off (OFF, high-impedance). The level set for INV is identical to the level for VAR, however, the phase of the curve is shifted by 180 deg.

Example: `:OUTP:Q INV` *RST value: OFF

:OUTPut:MARKer<n>[:STATe] ON | OFF

For what markers this command is active depends on the options installed in AMIQ.

If neither the "Rear I/Q Outputs" option (AMIQ-B19) nor the "Digital I/Q Output" option (AMIQ-B3) is installed, the rear-panel marker output designated by <n> (n = 1 to 4) is switched on or off by this command.
In the ON position, the output is either 0 V or +5 V depending on the marker data of the loaded waveform. In the OFF position, the output is high impedance.

If the "Rear I/Q Outputs" option (AMIQ-B19) is installed, marker outputs 3 and 4 are not available because these connectors are used for the Q and I output signals. The command has therefore no effect for marker outputs 3 and 4.

If both the "Rear I/Q Outputs" option (AMIQ-B19) and the "Digital I/Q Output" option (AMIQ-B3) are installed, marker 3 is available on data line Q0 and marker 4 on data line Q1 (see chapter 4, "Digital I/Q Output" option AMIQ-B3), but data lines Q0 and Q1 of AMIQ-B3 cannot be switched to high impedance with this command because AMIQ-B3 does not provide for this.

If the marker outputs are already switched on and a trace with a generation resolution of 16 bits {RESOLUTION 16,x} is loaded (see section „Waveform File Format on page 6.54 ff.), they then become switched off. If a trace with a generation resolution of 16 bits is already loaded, the marker outputs cannot be switched on.

In the two cases, no error message is issued because the tie-up between generation resolution and marker outputs is already taken into account in WinIQSIM.

The marker outputs can become switched on again when a trace with a generation resolution of 14 or 12 bits is loaded. The markers cannot be switched on either following the reduction of the output

resolution with the command OUTP:RES because a rounding algorithm is employed that cannot generate valid marker bits.

Example: `:OUTP:MARK3 OFF` *RST value: OFF

:OUTPut:MARKer<n>:DELay <samples>

shifts all markers of marker channel <n> (n = 1 to 4) by <samples>. If <samples> is less than 0, the markers are shifted towards the front (ie earlier in time), otherwise towards the end. This function has a "wrap around" which means that markers shifted out of the trace are coming in again at the opposite end. The marker data of a waveform file on the hard disk are not changed.

If the "Rear I/Q Outputs" option (AMIQ-B19) is installed, marker outputs 3 and 4 are not available because these connectors are used for the Q and I output signals. The command has therefore no effect for marker outputs 3 and 4, but no error message is output.

If both the "Rear I/Q Outputs" option (AMIQ-B19) and the "Digital I/Q Output" option (AMIQ-B3) are installed, marker 3 is available on data line Q0 and marker 4 on data line Q1 (see chapter 4, "Digital I/Q Output" option AMIQ-B3).

If a trace with a generation resolution of 16 bits {RESOLUTION 16,x} is already loaded (see section „Waveform File Format“ on page 6.54 ff.), this command will not be carried out. No error message is issued because the tie-up between the generation resolution of a trace and marker commands is already taken into account in WinIQSIM.

Example: `:OUTP:MARK2:DEL 100` *RST value: 0

:OUTPut:OIMPedance R50 | HIGH

determines the impedance of the AMIQ outputs switched off via the `OUTP:I|Q[:STATe] OFF` command. The commands is effective with and without option AMIQ-B2 (differential outputs). The output impedance is valid for both channels. The setting `R50` corresponds to `OUTP:I|Q VAR` and `OUTP:I|Q 0V`, while the setting `HIGH` implies that the output connectors are disconnected by means of a cutoff relay so that they become high-impedance connectors.

If the command is sent while the AMIQ outputs are switched on (`OUTP:I|Q FIX|VAR|INV`) it will define a preset value effective as soon as the outputs are switched off via `OUTP:I|Q OFF`.

Example `:OUTP:OIMP R50` *RST value: R50

:OUTPut:TYPE UNBalanced | BALanced

switches over between the outputs I and Q referred to ground (UNBalanced) and the differential outputs I and $\overline{I}$, Q and $\overline{Q}$ (BALanced).

The setting BAL requires option AMIQ-B2 (Differential Outputs) to be fitted.

UNBalanced: The level of 0 V to 1 V defined via `OUTP:I|Q:AMPL[:UNB] <numeric_value>` is equal to the amplitude V_p of the inner conductors of the BNC sockets I and Q referred to ground, measured at a terminating impedance of 50 Ω.

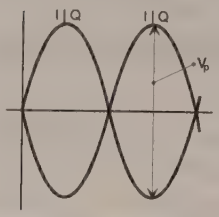
BALanced: The level of V to 4 V defined via `OUTP:I|Q:AMPL:BAL <numeric_value>` is equal to the amplitude V_{pp} of the inner conductors of the BNC sockets I and $\overline{I}$, Q and $\overline{Q}$ for a high-impedance termination.

Example `:OUTP:TYPE BAL` *RST value: UNB

:OUTPut:I:AMPLitude:BALanced 0V to 4V

(requires option AMIQ-B2 (Differential Outputs) to be fitted)

The command sets the peak amplitude V_p between the two inner conductors of the BNC sockets I and $\overline{I}$ for a *non-loaded* output. It is effective only for `OUTP:I VARiable` or `INVerted`.



If AMIQ is set to the UNBalanced mode, this command will define a preset level effective as soon as the instrument is switched over to the BALanced mode.

Example `:OUTP:I:AMPL:BAL 1V` *RST value: 0.5 V

OUTPut:Q:AMPLitude:BALanced 0V to 4V

(requires option AMIQ-B2 (Differential Outputs) to be fitted)

The command defines the peak-to-peak amplitude between the inner conductors of the BNC sockets Q and $\overline{Q}$ for a high-impedance termination. It is effective only if `OUTP:Q VARiable` or `INVerted` is set.

If AMIQ is set to the UNBalanced mode, this command will define a preset level effective as soon as the instrument is switched over to the BALanced mode.

Example `:OUTP:Q:AMPL:BAL 1V` *RST value: 0.5 V

:OUTPut:I:BIAS -2.5 to 2.5 V

(requires option AMIQ-B2 (Differential Outputs) to be fitted)

The command defines the DC offset (bias voltage) for the I channel and in the BALanced mode. The specified level remains effective if the I output is switched off (`OUTP:I OFF`), provided that the output impedance was set to 50 Ω by means of the command `OUTP:OIMP R50`.

If the output impedance was set to HIGH while the I output was switched off the output socket is cut off by a relay so that the BIAS setting is not effective.

Example `:OUTP:I:BIAS -0.2V` *RST value: 0 V

:OUTPut:Q:BIAS -2.5 to 2.5 V

(requires option AMIQ-B2 (Differential Outputs) to be fitted)

The command defines the DC offset (bias voltage) for the Q channel and in the BALanced mode. The specified level remains effective if the Q output is switched off (`OUTP:Q OFF`), provided that the output impedance was set to 50 Ω by means of the command `OUTP:OIMP R50`.

If the output impedance was set to HIGH while the Q output was switched off the output socket is cut off by a relay so that the BIAS setting is not effective.

Example `:OUTP:Q:BIAS -0.2V` *RST value: 0 V

:OUTPut:RESolution 8 to 16

Traces from version 3.10 and higher of WinIQSIM are generated with a resolution of 14 or 16 bits. Each trace receives the tag {RESOLUTION: x,y} where 'x' = generation resolution (bit width of trace generation in WinIQSIM) and 'y' = output resolution (bit width of trace to be output in AMIQ). The output generation can be modified after loading the trace and must always be ≤ the generation resolution. This command can be used independently of the option AMIQ-B3 (digital outputs). It can prove to be useful to reduce the resolution of the analog outputs for the purpose of investigating the response of a DUT. Reducing the output resolution has the effect of setting unused bits to 0, rounding the value and providing MSB-justified outputs at the digital I/Q output and at the 14-bit D/A converter.

Example: `:OUTP:RES 8` *RST value: 14

PROGram – Program Sequence Control

AMIQ is able to execute a sequence of IEC/IEEE-bus commands from a file. The file must contain a valid IEC/IEEE-bus command in each line. Empty lines and comment lines (beginning with a double cross) are ignored.

The batch files can be copied from a floppy to the internal hard disk of AMIQ from where they are executed. Contrary to the waveform files, no directories can be specified.

In most of the commands the parameter is a file name (<name>). Valid DOS names with up to 8 characters may be used, however without information on drive and path or extension (the extension .iec is automatically added). A directory must not be specified.

Note: *After power up of AMIQ, the autoexec.iec batch file, if any, is automatically executed from the floppy in the drive.*

Table 6-9 PROGram – Program sequence

Command	Parameter	Notes
:PROGram:COPY	<name>	Not SCPI, no query
:PROGram:DELete	<name>	
:PROGram:RUN | EXECute	<name>	

:PROGram:COPY <name>

copies the specified batch file from the floppy to drive C: of the AMIQ. It is not allowed to specify any drive names, paths, and file extensions; the default drive set via mit `MMEM:MSIS <drive>` is ignored. If a file with the same name already exists, the error message -288 <Illegal program name> is output.

Example: `:PROG:COPY "myprog"`

:PROGram:DELete <name>

searches first the floppy, then drive C: for the specified batch file and clears the file. It is not allowed to specify any drive names, paths, and file extensions; the default drive set via mit `MMEM:MSIS <drive>` is ignored.

Example: `:PROG:DEL "myprog"`

:PROGram:RUN | EXECute <name>

executes the batch file specified with <name>. <name> is first searched for on the floppy and then on the hard disk. It is not allowed to specify any drive names, paths, and file extensions; the default drive set via mit `MMEM:MSIS <drive>` is ignored.

`:EXECute` and `:RUN` have the same function.

Example: `:PROG:RUN "myprog"`

SOURce – Hardware Settings

The commands of this system modify the output signals.

The CORRection subsystem within the [:SOURce] system is a supplement to :CALibration. The commands serve for a fine adjustment of level offset and gain for :OUTP:MODE FIX (the settings are not effective for OUTP:MODE VAR and INV) and of the delay difference between the I and Q channels. This adjustment can be used to compensate for inaccuracies of external instruments and therefore for an overall system adjustment (see section "IQ Signal Adjustments" in chapter 4).

Note: *The keyword SOURce is optional in all subsequent commands and can be omitted as shown in the examples for the individual commands.*

Table 6-10 SOURce – Hardware settings

Command	Parameter	Notes
[:SOURce]:CLOCk	<frequency>[, mode]	Not SCPI
[:SOURce]:SCLock	EXTSlow | EXTFast | INTernal	nicht SCPI
[:SOURce]:CORRection:GAIN:I:FIXed	<value> -1.0 ... 1.0	
[:SOURce]:CORRection:GAIN:Q:FIXed	<value> -1.0 ... 1.0	
[:SOURce]:CORRection:OFFSet:I:FIXed	<value> -1.0 ... 1.0	
[:SOURce]:CORRection:OFFSet:I:VARiable	<value> -1.0 ... 1.0	
[:SOURce]:CORRection:OFFSet:Q:FIXed	<value> -1.0 ... 1.0	
[:SOURce]:CORRection:OFFSet:Q:VARiable	<value> -1.0 ... 1.0	
[:SOURce]:CORRection:SKEW	<value> -1.0 ... 1.0	Not SCPI
[:SOURce]:ROSCillator:SOURce	INTernal | EXTernal	

[:SOURce]:CLOCk <frequency>[, mode]

This command defines the clock frequency at which samples are read from the output buffer and applied to the output sockets via the D/A converters. Valid frequency values are from 10 Hz to 105 MHz. Valid mode values are SLOW and FAST. For frequencies below 2 MHz and above 4 MHz, the mode definition is ignored and can therefore be omitted.

For clock frequencies between 2 MHz and 4 MHz, the user can switch AMIQ to the desired clock frequency mode.

Clock frequency mode SLOW

This mode is automatically set if a clock frequency **below 2 MHz** is selected.

The advantage offered by this mode is in the small stepwidth for varying the stored waveform length. In the case of AMIQ model 03 the waveform length can be varied from **24** to 4,000,000, in the case of AMIQ model 04 from 24 to 16,000,000 **in steps of 1**.

For clock frequencies between 2 MHz and 4 MHz, both the SLOW and the FAST mode can be selected. The SLOW mode can be set with the command

CLOCK <frequency>,**SLOW**

Clock frequency mode FAST

This mode is automatically set if a clock frequency **above 4 MHz** is selected.

Please note that with this mode the waveform length can be varied **only in steps of 4,** i.e. in AMIQ model 03 from **24** to 4,000,000 and in AMIQ model 04 from 24 to 16,000,000. This means that the number of samples must be divisible by 4.

For clock frequencies between 2 MHz and 4 MHz, both the SLOW and the FAST mode can be selected. The FAST mode can be set with the command

`CLOCK <frequency>,FAST`

If waveforms are loaded that do not match the selected clock frequency mode in terms of minimum number of samples or steps, corresponding error messages are placed in the error queue.

If no mode is specified for a clock frequency between 2 MHz and 4 MHz, the previous mode is maintained.

This command causes switchover of the CLK connector on the rear panel so that it operates as an output, i.e. switchover is made from the external clock input mode (selected with `SCLock EXTSlow | EXTFast`) to internal clock. The command has the same effect as the command `SCLock INTernal`. In this way, control programs for older AMIQ models can also be run on AMIQ models 03 and 04, if these models are set to `SCLock EXTSlow | EXTFast`.

Example: `:CLOC 2.5MHZ, SLOW` *RST value: 3MHz, SLOW

Note: *Operation in the 'frequency' range above 100 MHz requires a reduced ambient temperature. Proper functioning of the instrument is guaranteed up to 100 MHz.*

[:SOURce]:SCLock EXTSlow | EXTFast | INTernal

The command SCLock EXTSlow | EXTFast switches the rear-panel BNC connector CLK as an input for an external clock. External clocking for the AMIQ models 03 and 04 is useful in conjunction with option AMIQ-B3 (digital I/Q output) and enables two operating modes:

1, integration of AMIQ in a system with system clock.

2, feeding the DUT (eg D/A converter) with a spectrally pure external clock while retaining the clock/data synchronization.

For details on external clocking, see chapter 4, section "External Clock". The command `SCLock INTernal` switches back to the internal clock (also the command `CLOCk frequency[, mode]`), and the rear-panel BNC connector *CLK* becomes a clock output (default setting).

AMIQ always starts with the internal clock setting `SCLock INT`. This setting is also effective after loading a setup.

This is necessary because it is not always the case that the external clock is present on the power-up of AMIQ. **The external clock mode must therefore be switched on first.**

The trigger command *TRG starts the data output at the clock mode set with `SCLock INTernal | EXTSlow | EXTFast` (see also chapter 4, Basic Modes of AMIQ):

`SCLock INTernal`: Clock mode SLOW or FAST using the frequency set with `CLOck xxxMHz`.

`SCLock EXTSlow`: Clock mode SLOW (suitable for clocks ≤ 4 MHz).

Clocks > 4 MHz can cause impairment of the trace. The external clock frequency is not monitored.

SCLock EXTFast: Clock mode FAST (suitable for clocks ≥ 2 MHz).

External clock frequency monitor: if the external clock frequency falls below 2 MHz, the SDRAM will be halted, warning 1270 "Waveform output stopped; external clock too low!" is saved in the error queue and the RUNNING LED goes off. Status bit 8 (SOURCE) of the operation register reflects the status of the RUNNING LED.

RUNNING LED off (trace output stopped) status bit 8 = 0,

RUNNING LED on (trace being output) status bit 8 = 1

The output of a trace is started again with TRIGger. It is not necessary to load the trace again!

If the external clock frequency is changed while a trace is being output, the clock frequency must be valid and stable 10 ms at the latest. Otherwise the trace output is stopped

Example: `:SCL EXTF` *RST value: INT

[:SOURce]:CORRection:GAIN:I:FIXed <value>

determines the gain factor for the I channel. It is only effective with `:OUTP:I[:STATe]` FIX set. <value> is specified without a unit. The permissible value range is -1.0 to 1.0, with 0.0 corresponding to a gain of 1.0. Simple conversion of setting values into gain factors is only possible for 0.0.

Example: `CORR:GAIN:I -0.1` *RST value: 0.0

[:SOURce]:CORRection:GAIN:Q:FIXed <value>

determines the gain factor for the Q channel. It is only effective when `:OUTP:Q[:STATe]` FIX is set. <value> is specified without a unit. The permissible value range is -1.0 to 1.0, with 0.0 corresponding to a gain of 1.0. Simple conversion of setting values into gain factors is only possible for 0.0.

Example: `CORR:GAIN:Q:FIX -0.1` *RST value: 0.0

[:SOURce]:CORRection:OFFSet:I:FIXed <value>

determines the offset for the I channel when the output mode FIXed (command `OUTPut:I[:STATe] FIXed`) is selected. <value> is specified without a unit. The permissible value range is -1.0 to 1.0, with 0.0 corresponding to the minimum offset. Limit values of the valid range are –30 mV and 30 mV (into 50 Ohm) with a step width of 30 µV.

Example: `CORR:OFFS:I:FIX -1` *RST value: 0.0

[:SOURce]:CORRection:OFFSet:I:VARiable <value>

determines the offset for the I channel when output mode VARiable (command `OUTPut:I[:STATe] VARiable`) or INVerted is selected. <value> is specified without a unit. The permissible value range is –1.0 to 1.0, with 0.0 corresponding to the minimum offset. The limits of the valid range depend on the setting of the mechanical attenuator set. When the level is changed that switches the attenuator, the offset of the output signals is changed as well. The following assignment applies:

Attenuator	Voltage (into 50 Ω) for setting -1	Voltage (into 50 Ω) for setting 1
0 dB	–70 mV	70 mV
20 dB	–7.0 mV	7.0 mV
40 dB	–0.70 mV	0.70 mV

The attenuator is set with command `OUTPut:I:AMPLitude`; it cannot be set or queried separately.

Example: `CORR:OFFS:I:VAR -0.1` *RST value: 0.0

[:SOURce]:CORRection:OFFSet:Q:FIXed <value>

determines the offset for the Q channel when the output mode FIXed (command `OUTPut:Q[:STATe] FIXed`). <value> is specified without a unit. The applicable value range is –1.0 to 1.0, with 0.0 corresponding to the minimum offset. The key values of the range are –30 mV and 30 mV (into 50 Ohm) with a step width of 30 µV.

Example: `CORR:OFFS:Q:FIX -0.1` *RST value: 0.0

[:SOURce]:CORRection:OFFSet:Q:VARiable <value>

determines the offset for the Q channel when the output mode VARiable (command `OUTPut:Q[:STATe] VARiable`) or INVerted is selected. <value> is specified without a unit. The applicable value range is –1.0 to 1.0, with 0.0 corresponding to the minimum offset. The assignment of limit values for the valid range depends on the position of the mechanical attenuator set. When the level is changed that switches the mechanical attenuator, the offset of the output signal is changed as well. The following assignment applies:

Attenuator	Voltage (into 50 Ω) for setting - 1	Voltage (into 50 Ω) for setting 1
0 dB	–70 mV	70 mV
20 dB	–7.0 mV	7.0 mV
40 dB	–0.70 mV	0.70 mV

The attenuator is set with command `OUTPut:Q:AMPLitude`; it cannot be set or queried separately.

Example: `CORR:OFFS:Q:VAR -0.1` *RST value: 0.0

[:SOURce]:CORRection:SKEW <value>

determines the delay between I and Q channel. Positive values delay the I channel compared to the Q channel. <value> is specified without a unit. The applicable value range is -1.0 to 1.0, with 0.0 corresponding to the minimum delay. The limits of the valid range are approx. –1 ns to 1 ns.

Example: `CORR:SKEW -0.5` *RST value: 0.0

[:SOURce]:ROSCillator:SOURce INTernal | EXTernal

switches the 10 MHz reference oscillator to internal or external 10 MHz synchronization. At the reference output always the signal generated by the internal reference oscillator is present.

Example: `:ROSC:SOUR EXT` *RST value: INT

STATus – Status Reporting

This path permits readout of information on operating states and errors occurred in the instrument. It can also be determined which status bits are set under which conditions (so that a Service Request is triggered, for instance). The meaning of the two registers and their individual bits and the elements of the register (*CONDition, EVENt, ENABle, PTRansition, NTRansition*) are described in the section "Status Reporting System" in chapter 5.

Note: *Resetting the instrument (*RST) does not clear these registers. For this reason no *RST values are specified. The registers can be reset with* `:STATus:PRESet`.

Table 6-11 Status reporting

Command	Parameter	Notes
:STATus:OPERation:[EVENt]?		Query only
:STATus:OPERation:CONDition?		Query only
:STATus:OPERation:ENABle	0 to 32767	
:STATus:OPERation:PTRansition	0 to 32767	
:STATus:OPERation:NTRansition	0 to 32767	
:STATus:QUEStionable[:EVENt]?		Query only
:STATus:QUEStionable:CONDition?		Query only
:STATus:QUEStionable:ENABle	0 to 32767	
:STATus:QUEStionable:PTRansition	0 to 32767	
:STATus:QUEStionable:NTRansition	0 to 32767	
:STATus:PRESet		

:STATus:OPERation[:EVENt]?

queries the *EVENt* register of the *STATus:OPERation* register. Reading clears this register.

Example: `:STAT:OPER?`

:STATus:OPERation:CONDition?

queries the *CONDition* register of the *STATus:OPERation* register. Since this register directly reflects the hardware, it is not cleared by reading.

Example: `:STAT:OPER:COND?`

:STATus:OPERation:ENABle 0 to 32767

enters a figure which is interpreted as a bit pattern in the *ENABle* register of the *STATus:OPERation* register. Setting a bit causes the event to be taken over into the sum bit in the status byte. The most-significant bit is not used.

Example: `:STAT:OPER:ENAB 32767`

:STATus:OPERation:PTRansition 0 to 32767

enters a number which is interpreted as a bit pattern in the *PTRansition* register of the *STATus:OPERation* register. Setting a bit causes a transition from 0 to 1 in the *CONDition* register (ie the occurrence of the corresponding event in the hardware) to be transferred into the *EVENt* register. The most-significant bit is not used.

Example: `:STAT:OPER:PTR 32767`

:STATus:OPERation:NTRansition 0 to 32767

enters a number which is interpreted as a bit pattern in the *NTRansition* register of the *STATus:OPERation* register. Setting a bit causes a transition from 1 to 0 in the *CONDition* register (ie the disappearance of the corresponding event in the hardware) to be transferred into the *EVENt* register. The most-significant bit is not used.

Example: `:STAT:OPER:NTR 0`

:STATus:QUEStionable[:EVENt]?

queries the *EVENt* register of the *STATus:QUEStionable* register. Reading clears this register.

Example: `:STAT:QUES?`

:STATus:QUEStionable:CONDition?

queries the *CONDition* register of the *STATus:QUEStionable* register. Since this register directly reflects the corresponding hardware it is not cleared by reading.

Example: `:STAT:QUES:COND?`

:STATus:QUEStionable:ENABle 0 to 32767

enters a number which is interpreted as a bit pattern in the *ENABle* register of the *STATus:QUEStionable* register. Setting a bit causes the event to be transferred into the sum bit in the status byte.

Example: `:STAT:QUES:ENAB?`

:STATus:QUEStionable:PTRansition 0 to 32767

enters a number which is interpreted as a bit pattern in the *PTRansition* section of the *STATus:QUEStionable* register. Setting a bit causes a transition from 0 to 1 in the *CONDition* register (ie the occurrence of the corresponding event in the hardware) to be transferred to the *EVENt* register. The most-significant bit is not used.

Example: `:STAT:QUES:PTR 32767`

:STATus:QUEStionable:NTRansition 0 to 32767

enters a number which is interpreted as a bit pattern in the *NTRansition* register of the *STATus:QUEStionable* register. Setting a bit causes a transition from 1 to 0 in the *CONDition* register (ie the disappearance of the corresponding event in the hardware) to be transferred to the *EVENt* register. The most-significant bit is not used.

Example: `:STAT:QUES:NTR 0`

:STATus:PRESet

sets the edge detectors (*PTRansition* and *NTRansition*) and the *ENABle* registers of the two status registers *OPERational* and *QUESTionable* to defined values:

- *PTRansition* is set to 32767 (0x7FFF), ie all hardware events are detected and transferred to the EVENt register.

  NTRansition is set to 0, ie the disappearance of a hardware event does not cause any change in the EVENt register.

  The *ENABle* registers are also set to 0, events are not transferred into the status byte (*STB?).

Example: `:STAT:PRES`

SYSTem – Various Settings

The commands of this chapter are configuration commands which do not directly affect signal generation.

Table 6-12 System settings

Command	Parameter	Notes
:SYSTem:BEEPer		
:SYSTem:BEEPer:STATe	ON | OFF	
:SYSTem:COMMunicate:GPIB:ADDRess	1 to 30	
:SYSTem:COMMunicate:SERial:BAUD	1200 | 2400 | 4800 | 9600 | 19200 | 38400 | 57600 | 115200	
:SYSTem:ERRor?		Query only
:SYSTem:LANGuage	FAST | SLOW	
:SYSTem:OPTion	<name>, <key> for AMIQ-B19: <name>,ON|INST|1 (installation) <name>,OFF|NA|-1 (deinstall.)	Not SCPI
:SYSTem:PRESet		
:SYSTem:STATe:CATalog?		Not SCPI, query only
:SYSTem:STATe:CATalog:LENGth?		Not SCPI, query only
:SYSTem:STATe:DELete	<name>	Not SCPI
:SYSTem:VERSion?		Query only

:SYSTem:BEEPer

triggers a single beep.

Example: `:SYST:BEEP`

:SYSTem:BEEPer:STATe ON | OFF

switches the beeper on or off. When the instrument is switched on a beep comes from the controller board which cannot be controlled by the AMIQ software.

Example: `:SYST:BEEP OFF` *RST value: ON

:SYSTem:COMMunicate:GPIB:ADDRess 1 to 30

sets the IEC/IEEE bus address of AMIQ. Upon delivery the address is set to 6. *RST does not overwrite this value.

Note: the IEC/IEEE-bus address can also be changed via a floppy disk if neither IEC/IEEE-bus nor serial interface is available. See also chapter 2.

Example: `:SYST:COMM:GPIB:ADDR 12`

:SYSTem:COMMunicate:SERial...

The following commands contain settings for the serial interface. Only the transmission speed can be set. The following values are preset: RTS/CTS handshake, no XON/XOFF, 8 data bits, no parity, 1 stop bit.

:SYSTem:COMMunicate:SERial:BAUD | 1200 | 2400 | 4800 | 9600 | 19200 | 38400 | 57600 | 115200

sets the transmission speed of the serial interface. This setting applies to both directions. The R&S software WinIQSIM determines the transmission speed set in the AMIQ by itself.

Example: `:SYST:COMM:SER:BAUD 115200` *RST value: 9600

:SYSTem:ERRor?

reads an error message from the error queue of the instrument and returns it to the controller. The read entry is cleared from the queue. The error queue is described in more detail in the section "Status Reporting System" in chapter 5.

Example: `:SYST:ERR?`

:SYSTem:LANGuage FAST | SLOW

switches into the high-speed transfer mode of the IEC/IEEE bus. Here the normal command parser is inactive. All incoming data bytes are directly forwarded to the program section which writes the waveform data into the output buffer. This means that I and Q samples must be sent directly after the switching command (raw data, *no* waveform data, no binary block data header). A transfer of commands is not possible in this mode. All settings made prior to switchover (eg also trigger source) remain valid. When at least one of the following event occurs, this mode is quit and the normal mode switched on again:

- the controller has set the EOI line
- the controller sets the device to local
- a device clear (DCL) is received.

As long as this mode is active, bit 1 of the status byte (STB) is set. Also in this mode the STB can be queried by a serial poll. If an error occurs in this mode, a respective error message is generated (which can be queried with `SYSTem:ERR?` after a return in the SCPI mode) and the command error bit in the SESR is set.

Example: `:SYST:LANG FAST` *RST value: SCPI

:SYSTem:OPTion <name>, <key>

permits the installation of software options. <name> is the name of the software option to be installed (AMIQB1, AMIQB19, AMIQK11, AMIQK12, AMIQK13, AMIQK14 or AMIQK15). <key> is a key number supplied together with the option. The name must be entered *without* a possible minus sign.

Exception: Installation of option AMIQB19 (I/Q Rear-Panel Connection):
AMIQB19 is a hardware option, however, AMIQ is not able to detect it by means of a hardware query. To inform the AMIQ's administration of options whether option AMIQB19 is fitted or not, the key code `INST|ON|1` must be entered when the option is fitted, otherwise `NA|OFF|-1`. No ordinary key number is used.

For an installed option, the key number can be re-read with the query form of the command: `SYST:OPT? <name>`

A list of installed options can be queried with :SYS:OPT? or *OPT?. A list of currently available options for AMIQ is given in the description of *OPT?

Example: Installation of an option:

```
:SYST:OPT AMIQB1, 12345678
:SYST:OPT AMIQB19,INST
```

Re-reading the key number of an installed option:

```
:SYST:OPT? AMIQB1
```

Response eg `123456789`

:SYSTem:PRESet

resets AMIQ to the factory-set state. The IEC/IEEE-bus address and the baud rate of the serial interface are not affected. The waveform file, batch files and device states stored with *SAV remain unchanged. The command is identical with *RST. A query does not exist.

Example: `:SYST:PRES`

:SYSTem:STATe

With these commands the device status memory (as created by *SAV and used by *RCL) is managed. A maximum of 100 memories are available.

:SYSTem:STATe:CATalog?

returns a list of device status memories available in the instrument, separated by commas. If no memories are available, a single blank is returned.

Example: `:SYST:STAT:CAT?`

:SYSTem:STATe:CATalog:LENGth?

returns the number of device status memories. This corresponds to the entries in the list generated by `:SYSTem:STATe:CATalog?`.

Example: `:SYST:STAT:CAT:LENG?`

:SYSTem:STATe:COPY <source>,<dest>

copies files recording the device status (characterized by the extension .CFG) on drive C: from <source> to <dest>. The default drive set via `MMEM:MSIS <drive>` is ignored.

The extension *.CFG may be omitted. Device status files are always stored in the AMIQ's default directory which is why no paths must be specified. Device status files copied from or to a floppy disk may have a specified path.

The command has no query form!

Examples:

```
:SYST:STAT:COPY 'SETUP','A:'
```
copy from AMIQ's setup directory to the root directory of the floppy disk with the same file name

```
:SYST:STAT:COPY 'SETUP.CFG','A:\'
```
copy from AMIQ's setup directory to the root directory of the floppy disk with the same file name

```
:SYST:STAT:COPY 'SETUP','A:\SUBDIR\'
```
copy from AMIQ's setup directory to a subdirectory of the floppy disk with the same file name

```
:SYST:STAT:COPY 'SETUP','A:\SUBDIR\MEMSET'
```
copy from AMIQ's setup directory to a subdirectory of the floppy disk with another file name

```
:SYST:STAT:COPY 'A:\SUBDIR\MEMSET','SETUP'
```
copy from a subdirectory of the floppy disk to AMIQ's setup directory with another file name

```
:SYST:STAT:COPY 'A:\SETUP','C:'
```
copy from the floppy disk to AMIQ's setup directory with the same file name

```
:SYST:STAT:COPY 'A:\SETUP','C:MEMSET'
```
copy from the root directory of the floppy disk to AMIQ's setup directory with another name

```
:SYST:STAT:COPY 'C:SETUP','C:MEMSET'
```
copy within AMIQ's setup directory

```
:SYST:STAT:COPY 'A:SETUP','A:MEMSET'
```
copy within the root directory of the floppy disk

:SYSTem:STATe:DELete <name>

clears a device status memory on drive C:. The default drive set via `MMEM:MSIS <drive>` is ignored, drive and path informatin are not permitted. The reserved memories PRESET and CURRENT cannot be cleared. If the name does not exist, the commands does not have any effect.

Example: `:SYST:STAT:DEL "mystat"`

:SYSTem:VERSion?

returns the *SCPI* version number valid for the instrument. Presently this is 1996.0. The *software* version number can be read with *IDN?.

Example: `:SYST:VERS?`

ARM/TRIGger/ABORt – Triggering, Sequence Control

The trigger system has been simplified compared to the SCPI model but was made compatible as far as possible: The *INITiate* step was omitted, the instrument behaves as if `:INITiate:CONTinuous ON` were permanently set.

Table 6-13 ARM/TRIGger/ABORt – Triggering, sequence control

Command	Parameter	Notes
:ABORt		
:ARM		
:TRIGger[:IMMediate]		
:TRIGger:SLOPe	POSitive | HIGH | RISing | NEGative | LOW | FALLing	
:TRIGger:MODE	OFF | GATed | SINGle | CONTinuous	Not SCPI
:TRIG:SOURce	MANual | BUS | EXTernal	

:ABORt

interrupts the current output. The device does not output signals until the next `:TRIG` command is given. Until this command is received, the idle signal defined by the IDLE SIGNAL tag in the loaded waveform is output (see "Waveform File Format" section below). If the loaded waveform contains no IDLE SIGNAL tag, the idle value of the last waveform containing an IDLE SIGNAL tag is set.

Example: `:ABOR`

:ARM

The command

- stops the waveform output,
- activates the output buffer so that the waveform output is started from the beginning upon the next trigger event,
- waits for a trigger event.

Until the trigger event, the idle signal defined by the IDLE SIGNAL tag in the loaded waveform is output (see "Waveform File Format" section below). If the loaded waveform contains no IDLE SIGNAL tag, the idle value of the last waveform containing an IDLE SIGNAL tag is set.

When the trigger event occurs, waveform output is started from the beginning.

This command is mandatory for the `TRIG:MODE GATed` mode of the trigger system (see corresponding description). For all other modes the `TRIG command` as a rule suffices to start waveform output.

Example: `:ARM`

:TRIGger[:IMMediate]

displays the trigger event. If the output buffer is active (with `ARM`), AMIQ starts to output signals after having received this command irrespective of the trigger source - ie also with `:TRIG:SOUR EXT`. This command has the same effect as *TRG or the interface message Group Execute Trigger (GET), with the exception that GET does not have any effect when `:TRIG:SOUR` is set to `EXT`.

Example: `:TRIG`

:TRIGger:SLOPe POSitive | HIGH | RISing | NEGative | LOW | FALLing

determines the edge or level at the external trigger connector as trigger event. In the `:TRIG:MODE GATed` mode AMIQ uses level triggering, ie the signal is output as long as the set level is present at the trigger connector. In all other operating modes, AMIQ uses edge triggering, ie the signal output is started when the level changes in the specified direction.

Note: *Two states are distinguished within the device. The POSitive, HIGH and RISing values are equivalent, the same applied to NEGative, LOW and FALLing. POS or NEG is always returned after the `:TRIG:SLOP?` query.*

Example: `:TRIG:SLOP FALL` *RST value: POS

:TRIGger:MODE OFF | GATed | SINGle | CONTinuous

determines the operating mode of the trigger system.

OFF: No triggering, no data are output. Waveform output is stopped, see **"Idle signal during stopped waveform output".**

GATed: For the GATed mode to be activated, it is necessary to switch to external triggering with the `TRIG:SOUR EXT` command and to set the level at the external trigger connector with the `TRIG:SLOP` command, which enables waveform output. The GATed mode is enabled with the `ARM` command. If the level set with `TRIG:SLOP` is present at the external trigger connector, waveform output is started with the first point of the waveform and is repeated continuously. If the level is changed, waveform output is stopped, see **"Idle signal during stopped waveform output".** If the level at the external trigger connector is changed again (minimum waiting time 100 µs), waveform output is restarted with the first point of the loaded waveform.
To enable waveform output in the GATed mode with a level of 0 V at the external trigger connector, the following command sequence has to be output:

```
TRIG:SOUR EXT
TRIG:MODE GAT
TRIG:SLOP LOW
ARM
```

A simple test can be made by connecting the inner conductor with the outer conductor of the external trigger connector by actuating a key. When the key is pressed, the waveform is output, when the key is released, the idle signal is output.

SINGle: The complete waveform is output once (starting with the first point and ending with the last point of the waveform), then the output is stopped, see **"Idle signal during stopped waveform output".** The next trigger event will restart waveform output from the beginning. Retriggering during a waveform output is not possible.
Waveform output can be triggered internally by means of a `TRIG` command and by an edge at the external trigger connector:

Single shot with internal trigger:

```
TRIG:SOUR BUS
TRIG:MODE SING
TRIG
```

Each TRIG command triggers a single-shot waveform output.

Single shot with external trigger:

```
TRIG:SOUR EXT
TRIG:SLOP FALL
TRIG:MODE SING
```

A simple test can be made by connecting the inner conductor with the outer conductor of the external trigger connector by actuating a key. When the key is pressed, a single-shot waveform output is triggered by a falling edge.

CONTinuous: Waveform output is started with the first point of the waveform and repeated continuously. At the end of the waveform, the output is continued immediately with the first point. Any trigger events as well as the trigger source (`TRIG:SOUR`) and edge settings (`TRIG:SLOP`) are ignored. The output signal is present at the I/Q outputs immediately upon a waveform is loaded with the `MMEM:LOAD RAM,'filename'` command.

Idle signal during stopped waveform output

The idle signal defined by the IDLE SIGNAL tag in the loaded waveform (see "Waveform File Format" section below) is present at the output connectors when waveform output is stopped with `TIRG:MODE OFF` or during the time AMIQ waits for a trigger signal (`TRIG:MODE GATed` or `SINGle` mode). If the loaded waveform contains no IDLE SIGNAL tag, the idle value of the last waveform containing an IDLE SIGNAL tag is set.

Example: `:TRIG:MODE CONT` *RST value: CONT

:TRIG:SOURce MANual | BUS | EXTernal

This command determines the trigger source:

MANual or BUS: GET or *TRG or :TRIGger[:IMMediate] via the IEC/IEEE bus or the RS-232 interface.

EXTernal: external triggering via connector

Example: `:TRIG:SOUR EXT` *RST value: MAN

Waveform File Format

File format

Waveforms are stored as DOS files on the device-internal hard disk and on floppies. The same format is used in the two cases and also for transmission via the IEC/IEEE bus and the serial interface, in the latter case packed in a binary block command. The file name extension is always .WV.

Tags

A tag-oriented format is used. Tags are self-contained information units. They have the general format

{Name: Data} or **{Name-length: Data}**

The colon separates the name and data sections. For the sake of clarity the colon is always followed by a blank.

Name identifies the day. It is always specified in upper-case characters.

Data are tag-specific but in most cases plain text in ASCII format.

Length indicates the number of bytes of the WAVEFORM tag and consists of:

	number of digits of the **Start** value	(1 to 7)
+	length of ", #"	(2 bytes)
+	number of I/Q pairs * 4	(2 bytes for each I- and Q-value).

Several tags in one file

Tags may be interleaved. Normally the order of the tags within a file is irrelevant, but there may be exceptions. All tags can but need not be contained in a waveform file. Exceptions are described with the individual tags.

Unknown tags are not evaluated by AMIQ but are stored unchanged and without an error message and can be read again.

The following tags are defined:

{TYPE: magic, xxxxxxxx} **<indispensable>**

The TYPE tag identifies this file as a valid AMIQ file. The tag must be the first tag in the file. xxxxxxxx is an ASCII-coded checksum over the data range of the *WAVEFORM* tag in this waveform (if the waveform contains several *WAVEFORM* tags, the checksum refers to the first one). It is calculated by the following alogorithm where 'start' is a pointer to the first byte after the double dagger '#' sign in the *WAVEFORM* tag and 'length' denotes the number of bytes between 'start' and the final brace (excluding the latter; 'length' must be a multiple of 4):

```
UINT32 checksum(void *start, UINT32 length)
 {
 UINT32 i, result = 0xA50F74FF;

 for(i=0; i < length/4; i++)
  result = result ^ ((UINT32 *)start)[i];

 return(result);
 }
```

The checksum is used for recognizing transmission errors. If the *TYPE* tag contains 0 or a non-numerical value for the checksum, it is ignored by the AMIQ.

'magic' identifies the type of the waveform file and can assume the following three values:

WV The file is a complete, selfcontained waveform file. When already available on the target medium, the previous version is overwritten.

WV-ADD This file is an additional update of an existing file the name of which is obtained from the *TARGET* tag. The copyright tag of an update file must have the same contents as the target file. The *MARKER LIST* and *WAVEFORM* tags are combined with their counterparts in the target. The tag *DATE* is not permissible and causes an error message. Combining overlapping marker lists is not allowed! For a detailed description of the combination of curves refer to section *Example of combining waveform files:* on page 6.63.

Note: *Because of the flexible, tag-based form of the waveform files, a version number is not required.*

{TARGET: name} **(mandatory for TYPE = WV-ADD)**

This tag specifies the target waveform file for which this update should be used. This is only useful for the WV-ADD and WV-REPLACE types, and for these types it is prescribed. When an update file does not include this tag, the whole update file is aborted and an error message generated. See Example of combining waveform files: *on page 6.63*.

{CLOCK: frequency[,SLOW | FAST]} **(optional)**

This tag specifies the clock frequency with which the waveform should be output. The effect of the tag and the syntax of the `number` and `SLOW | FAST` parameters correspond to the remote-control command `[:SOURce]:CLOCk` and over from external to internal clock.

If one intends to load a waveform file containing the CLOCK tag and to supply the output signal with an external clock, the command `SCLock EXTxxx` must be executed after the waveform is loaded.

Beispiel:
```
MMEM:LOAD RAM,'SINE'
SCLock EXTFast
```

A query of `SOURce:CLOCk?` after loading the waveform returns the values set by means of the `{CLOCK:...}` tag.

{COMMENT: string} **(optional)**

The tag contains a plain-text ASCII string of any length. The string is not evaluated in the AMIQ, it serves for the output of keywords on the PC and for describing the waveform. The string may contain all printable ASCII characters except the closing brace.

{COPYRIGHT: string} **(important for TYPE = WV-ADD)**

This tag contains the name under which WinIQSIM (or other programs for waveform generation) are registered. The string may contain all printable ASCII characters except the closing brace. To put curves together with TYPE:WV-ADD, the COPYRIGHT strings of the curves must correspond.

{DATE: yyyy-mm-dd;hh:mm:ss} **(optional)**

This tag contains date and time at which the waveform file was generated. The year should be specified with four digits. AMIQ does not evaluate this tag.

{FILTER: value} **(optional)**

Specifies which output filter should the looped into the output filter. The tag is valid simultaneously for the two channels; it duplicates the function of the remote-control command `:OUTP:FILT`. Permissible values are OFF, 2.5 MHz, 25 MHz and EXT.

{MARKER LIST x: start-end:value;...} Specification of marker ranges **(optional)**
{MARKER LIST x: start:value;...} Specification of marker changes

This tag contains the marker list for channel x. The format is described in detail in the *:MARKer* subsystem; numbering is identical with the numeric suffix of the *:MARKer* subsystem. Markers can also be directly set in the IQ data (in the two least-significant bits of each I and Q sample).

The marker list is not loaded if a RESOLUTION tag with an output resolution of 16 is specified before the marker tag.

In the case of a conflict between the marker values from a waveform loaded via the commands `MMEM:LOAD RAM,<filename>` or `MEM:[illegible],<Binärblock>` (and included in the data bits d0 and d1), and the marker values from a marker list loaded **afterwards** via the tag {MARKER LIST}, the markers from the list have the priority.

If the marker values of a marker list (eg {[illegible]ST 1: '100-101:0;100-101:1'}) do not correspond, the last setting is valid.

Example: Two equivalent marker configurations.
set by specifying the marker ranges:
{MARKER LIST 1: 0-9:0,10-19:1;20-29:0;30-39:1}
set by specifying the marker changes:
{MARKER LIST 1: 0:0;10:1;20:0;30:1}

{WAVEFORM-length: start,#xxxxxxxxxxxx...} **<indispensable>**

This tag contains the actual waveform data

The quantity ***length*** indicates the number of bytes of the WAVEFORM tag and consists of:

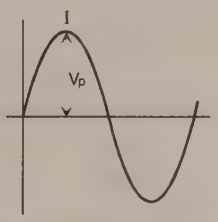
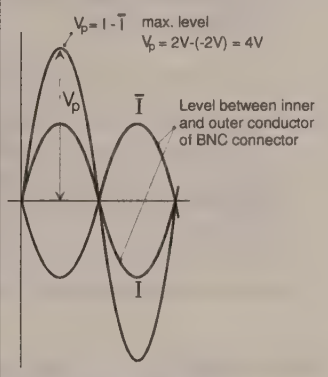
	number of digits of the **start**-value	(1 to 7)
+	length of ", #"	(2 bytes
+	number of I/Q pairs * 4	(2 bytes for each I and Q-value).

Example:
{WAVEFORM-403:[illegible]0,#[illegible] ..... [illegible]
403 Bytes

start specifies the address from which onwards the subsequent samples should be stored in the output buffer. Thus a waveform can be transferred to the AMIQ little by little. xxxxxxx... are binary(!) data, that alternately contain I and Q samples, the first sample being a I sample. Each sample consists of two bytes, the least-significant one (LSByte) is the first. The lowest two bits of each sample contain marker data (refer to chapter 4 as for the assignment of bits to marker data). The *WAVEFORM* tag must be contained in the waveform file. The two may be present at the same time. Several *WAVEFORM* tags are also permissible. In this case the union set of the data will be used. In the case of overlapping tags, the data of the last tag are valid.

The two bytes of a sample cover the value range 0x300 ... 0xFD00 (0x768 ... 64768). This value is transferred to the D/A converter unchanged

Depending on the setting of `OUTP:[illegible]` different output levels are applied to the output connectors of AMIQ:

	Binary value of the sample identical with the value of the waveform D/A converter	Asymmetric outputs amplitude V_p at 50 Ω between inner and outer conductor of I and Q output  Valid as Q output also!	Symmetric outputs of option AMIQ-B2 (Differential Outputs) amplitude V_p between the inner conductors of the non-loaded output sockets I and $\overline{I}$, Q and $\overline{Q}$.  Valid as Q output also!
OUTP:I FIX OUTP:Q FIX	0x300 (768) 0x8000 (32768) 0xFD00 (64768)	-0.5 V 0 V 0.5 V	-2 V 0 V 2 V
OUTP:I VAR OUTP:Q VAR OUTP:I INV OUTP:Q INV Level same as VAR, phase shifted by 180°	0x300 (768) 0x8000 (32768) 0xFD00 (64768)	-1 V 0 V 1 V	-4 V 0 V 4 V

{IDLE SIGNAL: I, Q} **(optional)**

This tag defines the idle signal , i.e. the two ASCII-coded 16 bit values output while the waveform is already in the output buffer but not yet being output because AMQ is waiting for a trigger event, for example in the `TRIGger:MODE GATed` or `SINGle` mode, or because waveform output has been stopped, for example in the `TRIGger:MODE OFF` mode.

If the loaded waveform contains no IDLE SIGNAL tag, the idle value of the last waveform containing an IDLE SIGNAL tag is set.

Level values at the I and Q outputs (50 Ω between inner and outer conductor) for various characteristic 16-bit values:

With OUTP:I FIX and OUTP:Q FIX setting:

{IDLE SIGNAL: 65535, 65535}	0.512 V
{IDLE SIGNAL: 64768, 64768}	0.5 V
{IDLE SIGNAL: 32768, 32768}	0 V
{IDLE SIGNAL: 768, 768}	-0.5 V
{IDLE SIGNAL: 0,0}	-0.512 V

With OUTP:I VAR and OUTP:Q VAR setting and output level of 1 V:

{IDLE SIGNAL: 65535, 65535}	1.024 V
{IDLE SIGNAL: 64768, 64768}	1.000 V
{IDLE SIGNAL: 32768, 32768}	0 V
{IDLE SIGNAL: 768, 768}	-1.000 V
{IDLE SIGNAL: 0,0}	-1.024 V

For open-circuited outputs, the output levels are twice as high.

{RESOLUTION: x,y} (can be selected)

Traces from version 3.10 and higher of WinIQSIM are generated with a resolution of 14 or 16 bits. Each trace receives the new tag {RESOLUTION: x,y} where

'x' = generation resolution (bit width of trace generation in WinIQSIM) and

'y' = output generation (bit width of trace to be output in AMIQ).

Markers can be used without any restriction for traces generated with a resolution of 12 or 14 bits. With traces of 16-bit generation resolution, however, the markers cannot be used because data bits d0 and d1 are allocated as the LSB bits of the I/Q values.

The RESOLUTION tag must be placed **always in front of** the MARKER LIST tag because the generation resolution of the trace must be known at the time of marker list processing. Traces with 16-bit generation resolution must not have a marker list. If they do, the list will be ignored, active markers get switched off and any marker commands rejected.

A generation resolution of 16 bits has no relevance for the analog I/Q outputs; in analog operation same as before d2 ... d15 go to the 14-bit D/A converter. The higher resolution can be fully exploited only together with the digital I/Q option (AMIQ-B3) and permits a 12-dB higher resolution than at the analog output.

The output resolution (y) specified with {RESOLUTION: x,y} can subsequently be modified in AMIQ using the IEEE 488 command `OUTPut:RESolution 8...16` and must always be ≤ the generation resolution.

The command `OUTPut:RESolution 8...16` can be used independently of the digital I/Q output option (AMIQ-B3) and can be quite useful to reduce the output resolution of the analog outputs to observe the DUT's response.

Reducing the output resolution has the effect of setting unused bits to 0 and rounding the value. The value is always output MSB-justified at the digital I/Q output and at the 14-bit D/A converter.

Creating a Waveform File „Manually“

We will use to example of a sine function in the I channel and a cosine function in the Q channel, each with 20 points, to explain how a waveform file SICO.WV is generated.

The sine and cosine values are calculated by a short program written in the programming language C (see annex to this section on page 6.62). They are stored in the file SICO.TXT as follows:

Contents of SICO.TXT:

```
Sine (I)     Cosine (Q)
0.000000 1.000000
0.309017 0.951057
0.587785 0.809017
0.809017 0.587785
0.951057 0.309017
1.000000 -0.000000
0.951056 -0.309017
0.809017 -0.587785
0.587785 -0.809017
0.309017 -0.951056
-0.000000 -1.000000
-0.309017 -0.951057
-0.587785 -0.809017
-0.809017 -0.587785
-0.951056 -0.309017
-1.000000 0.000000
-0.951056 0.309017
-0.809017 0.587785
-0.587785 0.809017
-0.309017 0.951057
```

The decimal values in SICO.TXT should be normalized such that they are in the between –1.0 and +1.0.
The AMIQ waveform file SICO.WV will be based on the contents of this file.

To be read by AMIQ these waveform data must be coded binary and packed into an appropriate WAVEFORM information unit.

AMIQ recognizes a great variety of information units called tags. A tag consists of a name and a data set and is enclosed in curved brackets. The tag is a kind of label carrying the information what AMIQ should do with the data set (see also section „Waveform File Format“ on page 6.54 and step 3 of the following instructions).

The following steps outline how to create the waveform file SICO.WV:

Step 1

The values from the file SICO.TXT must be converted into binary format consisting of integer numbers without a sign a with 16-bit width. The numeric range between –1.0 and +1.0 corresponds to the modulation range of the waveform D/A converter of 64000.

+1.0 →	64768	⎫
0.0 →	32768	⎬ 64000
-1.0 →	768	⎭

A further C-program is suitable for creating the binary data set from the ASCII values stored in SICO.TXT file (see annex to this section on page 6.62). This program stores the binary data set to a file called SICO.WV.

The contents of the file SICO.WV reads as follows:

IQIQIQIQIQIQI ... IQ

Explanation: *There is no readable representation for binary values in this document. This is why we use the sequence IQIQIQ to characterize the binary code in the present example.*

Step 2

The file SICO.WV contains now the binary data set corresponding to the 20 I/Q pairs. Before this binary data set can be further processed in step 3, the TYPE tag

{TYPE: WV, xxxxxxx} must be placed in front.

The TYPE tag must be the first entry in a WAVEFORM file. The TYPE tag identifies the file as a valid AMIQ file.

WV	denotes that the file contains a curve which is closed upon itself.
xxxxxxx	is the checksum of the waveform file. To simplify our example **0** is used, i.e., AMIQ does not evaluate a checksum.

To enter the TYPE tag in the SICO.WV file, an ASCII editor is to be used which can handle binary data too, e.g. Microsoft Windows editor WORDPAD.EXE. The Microsoft Windows editor NOTEPAD.EXE is not recommended, since it changes the binary data!

Now the contents of the SICO.WV file read:

```
{TYPE: WV, 0}
IQIQIQIQIQIQIQIQIQI ... IQ
```

Step 3

The binary data must now be packed into a WAVEFORM tag with the following structure:

{WAVEFORM-Length:␣Start,#*IQIQIQIQIQIQIQIQIQI ... IQ*}

The WAVEFORM tag consists of the following characters and data:

{	Opens each tag.
WAVEFORM	Name of the tag for waveform files.
-	Separates the name from the length indication.
Length	Length of the data set **Length** indicates the number of bytes of the data set and consists of: number of digits of the **Start**-value (1 to 7, in our example 1) + length of ", #" (2 bytes) + number of I/Q pairs * 4 (2 bytes for each I- and Q-value). In our example containing a sine and a cosine with 20 pairs for each wave and with the start address 0 in the AMIQ's output memory, the resulting length is **83**.
:␣	Separates the name and length from the remainder of the data set. The blank ␣ can be omitted.
Start	Address in the output memory of AMIQ used to store the following samples. In our example and most applications, this will be '0'.
,#	Indicates the beginning of the binary data.
IQIQIQ	Binary data set. The binary data contain the I and Q values in alternate order, the first value is an I value. Each value consists of 2 Bytes, starting with the least significant bit.
}	Terminates each tag.

The editor mentioned above which can handle binary data is now used to place the string "{WAVEFORM-83:␣0,#" in front and '}' at the end of the data set.

The contents of the waveform file SICO.WV for 20 I/Q pairs and start address 0 in the AMIQ's RAM is now ready for operation and reads.

```
{TYPE: WV, 0}                          ┌──── 20 I/Q pairs = 80 bytes ────┐
{WAVEFORM-83:␣0,# I Q I Q I Q I Q ... I Q }
                 └──────────────── 83 bytes ────────────────┘
```

The tags TYPE and WAVEFORM are mandatory for each waveform file. All other tags described in section „Waveform File Format" on page 6.54 are optional and can be inserted after the TYPE tag in arbitrary order, e.g.

```
{TYPE: WV,0}
{COMMENT: I/Q=sine/cosine, 20 points, clock 10 MHz}
{CLOCK: 10e6}
{FILTER: 2,5MHz}
{WAVEFORM-83:␣0,#IQIQIQIQIQIQ ... IQ}
```

Converting a Waveform File with the Application Software AMIQ-K2

The application software AMIQ-K2 from R&S is distributed free of charge and allows to convert a large variety of I/Q data sets to AMIQ waveform files. Moreover, AMIQ-K2 can be used to remote-control some important AMIQ functions, to load and to store curves.

This application software is available in the internet (http://www.rsd.de) under the path:

Products →
Test and Measurement →
Signal Generation →
IQ modulation generator AMIQ →
or
IQ simulation software WinIQSIM →

or from each R&S representative.

The control sequence

Select Source Files(s)
Type Mathcad (mixed)
Source File SICO.TXT
Transmit
Destination
WV formatted SICO.WV

allows to quickly generate a waveform file that is ready to operate from the file SICO.TXT containing the I/Q pairs in alternate order.

Annex:

C-program for creating the file SICO.TXT containing 20 sine and cosine pairs:

```
#include <stdlib.h>
#include <stdio.h>
#include <math.h>

void main (void)
{
#define SAMPLES 20
int i;
float grad,rad;
FILE *logging_fp;

logging_fp = fopen("SICO.TXT", "w");

for (i = 0; i < SAMPLES; i++)
 {
  grad = (360.0 / (float)(SAMPLES)) * (float)i;
  rad = grad * (3.141592654/180.0);
  fprintf (logging_fp,"%f %f\n",sin(rad),cos(rad));
 }
fclose(logging_fp);
}
```

Contents of the file SICO.TXT:

Sinus (I)	Cosinus (Q)
0.000000	1.000000
0.309017	0.951057
0.587785	0.809017
0.809017	0.587785
0.951057	0.309017
1.000000	-0.000000
0.951056	-0.309017
0.809017	-0.587785
0.587785	-0.809017
0.309017	-0.951056
-0.000000	-1.000000
-0.309017	-0.951057
-0.587785	-0.809017
-0.809017	-0.587785
-0.951056	-0.309017
-1.000000	0.000000
-0.951056	0.309017
-0.809017	0.587785
-0.587785	0.809017
-0.309017	0.951057

Extract from a C-program generating a binary data set from the I/Q pairs in the file SICO.TXT and storing the result to file SICO.WV:

```
 :
FILE *fp_sour_i,*fp_sour_q,*fp_dest;
unsigned int i_uint, q_uint;
 :
fp_sour = fopen("SICO.TXT", "rt" );
fp_dest = fopen("SICO.WV",  "wb" );
 :
while (1)
 {
  //Read I/Q pair from ASCII file
  if (fscanf (fp_sour,"%f %f",&i_float, &q_float) == EOF)
   break;

  //Convert I/Q pair to unsigned integer
  i_uint = (unsigned int)(32768.0 + (i_float*32000.0)+0.5);
  i_uint &= 0xFFFC; //Mask marker bits
  q_uint = (unsigned int)(32768.0 + (q_float*32000.0)+0.5);
  q_uint &= 0xFFFC; //Mask marker bits

  //Write converted I/Q pair to waveform file
  fwrite (&i_uint,1,2,fp_dest);
  fwrite (&q_uint,1,2,fp_dest);
}
 :
```

Example of combining waveform files:

The curves DUAL_S0.WV and DUALTONE.WV are to be combined and stored in the AMIQ under the name DECTDUAL.WV.
The two curves are already on the AMIQ.
DUAL_S0.WV can be kept there whereas DUALTONE.WV is required in the controller. The file is copied onto a disk by means of the command
MMEM:COPY 'DUALTONE.WV','A:DUALTONE.WV' (copying works because DUALTONE.WV is not coded).
On the controller, the file DUALTONE.WV is converted to a batch file named DUALADD.IEC with a binary editor, and the file has the following structure:

DUALADD.IEC

MMEM:DATA 'DECTDUAL.WV',#3862
{**TYPE: WV-ADD**,0}
{**TARGET: DECT_S0.WV**}
{COMMENT: Dual tone, 128 points, 0.9 MHz, 1.1 MHz at clock 12.8 MHz}
{**COPYRIGHT: 1998 Rohde&Schwarz (WINIQSIM)**}
{CLOCK: 12.8e6}
{IDLE SIGNAL: 32768, 32768}
{**WAVEFORM-520: 184320**,#<binary data set>}

MMEM:DATA:
The command takes over a waveform file in the binary block format and stores it under DECTDUAL.WV. Since the waveform file is a curve of the type WV-ADD, the latter is combined with the curve indicated under TARGET and then stored under DECTDUAL.WV.

DECTDUAL.WV:
Name of the curve containing the two curves to be combined.
#3862:
#3862: 3: number of digits of the following length indication.
#3**862**: 862: length of the following binary data set in bytes. To determine this length indication easily the data set should be stored in a file as from {TYPE:WV_ADD; the exact length of this file can be determined with the DOS command DIR.

TYPE: WV-ADD:
Denotes the curve from batch file DUALADD.IEC as a curve which is to be added to the curve indicated under TARGET.

TARGET: DECT_S0.WV:
Specifies the waveform file to which the curve from batch file DUALADD:IEC is to be added.

COPYRIGHT: 1998 Rohde&Schwarz (WINIQSIM):
The COPYRIGHT string of target waveform file DECT_SO.WV and the curve DUALTONE.WV to be added should match.

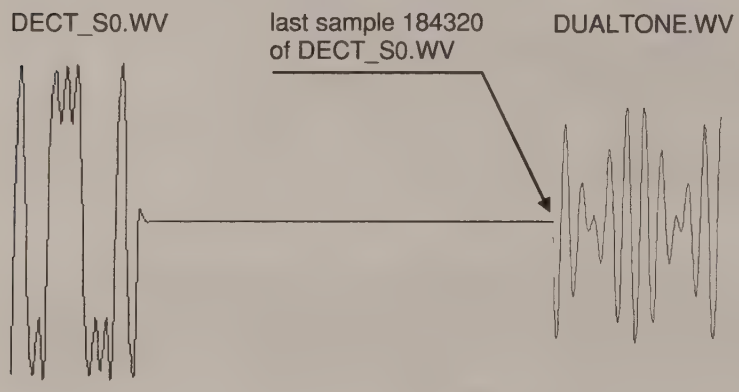
WAVEFORM-520: 184320,# <binary data set>:
In DUALTONE.WV the waveform tag is indicated with a length of 515 (WAVEFORM-515: 0,#<binary data set>). The value preceding ",#" (184320) indicates the start address of target waveform file DECT_SO.WV to which curve DUALTONE.WV is to be added. It is important to know how many samples a curve is made of. There are **184320** samples in the case of DECT_S0.WV. This value is generally known even if curves generated by the user are used. New WinIQSIM files contain the tag SAMPLES from which the number of samples of a curve can be immediately obtained.
If the value is unknown, it should be determined from the length indication behind the tag WAVEFORM of curve DECT_S0.WV.
Number of samples = length indication after WAVEFORM (737283) – number of digits of start value 0 (1) – 2) / 4!
Number of samples = (737283 – 1 – 2) / 4
Number of samples = 184320
The value **184320** is to be indicated after WAVEFORM as start value for the curve to be added.

The original curve DUALTONE.WV has indicated 0 as start value and a length of 515 bytes. Since the start value has increased by 5 digits from 0 to 184320, the waveform length should also be increased by 5 from 515 to **520**.

Store this data set on disk under DUALADD.IEC and insert the disk into the AMIQ.

Enter the command PROG:EXEC 'A:DUALADD.IEC' on the controller. The curves DUAL_S0.WV and DUALTONE.WV are combined and stored in the AMIQ under the name DECTDUAL.WV.

The sequence of commands
MMEM:LOAD RAM,'DECTDUAL.WV'
ARM
TRIG
loads the curve DECTDUAL.WV and the following signal appears at the output of the AMIQ:



Manually combined waveforms

List of Commands

The list contains all AMIQ remote-control commands in alphabetical order. A list of tags for determining the waveform file formats follows at the end of this table.

Remote-control commands

Table 6-14 List of all remote-control commands

Command	Parameter	Page
:ABORt		6.51
:ARM		6.51
:BERT:COPY	<name>	6.9
:BERT:DELete	<name>	6.9
:BERT:RESult?		6.9
:BERT:SELect	<name>	6.10
:BERT:SETup:CLOCk[:POLarity]	RISING FALLING	6.11
:BERT:SETup:DATA[:POLarity]	NORM INVerted	6.11
:BERT:SETup:DENable	OFF HIGH LOW	6.11
:BERT:SETup:MASK	OFF HIGH LOW	6.11
:BERT:SETup:MCOunt	1 ... 2^31-1	6.11
:BERT:SETup:MERRor	1 ... 2^31-1	6.12
:BERT:SETup:RESTart	INTerna EXTernal	6.12
:BERT:SETup:TYPE	PRBS9 PRBS11|PRBS15|PRBS16|PPRBS20|PRBS21|PRBS23	6.10
:BERT:STARt		6.12
:BERT:STOP		6.12
:CALibration:ALL?		6.14
:CALibration:AMPLitude:I:VALue?		6.14
:CALibration:AMPLitude:I?		6.14
:CALibration:AMPLitude:Q:VALue?		6.14
:CALibration:AMPLitude:Q?		6.14
:CALibration:AMPLitude:VALue?		6.14
:CALibration:AMPLitude?		6.14
:CALibration:DIAGnose	0 9000 to * 1000	6.15
:CALibration:OFFSet:I:VALue?		6.15
:CALibration:OFFSet:I?		6.15
:CALibration:OFFSet:Q:VALue?		6.15
:CALibration:OFFSet:Q?		6.15
:CALibration:OFFSet:VALue?		6.15
:CALibration:OFFSet?		6.15
:CALibration:ROSCillator	0 to 4095	6.16
:DIAGnostic:ABOard:ID?		6.17
:DIAGnostic:SELFtest...?		6.18
:DIAGnostic:TPOint<n>?		6.17
:MARKer<n>[:LIST]	<marker list>	6.21
:MEMory:DATA	RAM <binary block data>	6.24

:MEMory:DATA?	RAM[<tag>]	6.24
:MEMory:NAME?		6.25
:MMEMory:CATalog:LENGth?		6.25
:MMEMory:CATalog|DIRectory?		6.25
:MMEMory:CDIRectory|CD	<directory>	6.26
:MMEMory:COPY	<filename>[,<destination>]	6.26
:MMEMory:DATA	<filename>, <binary block data>	6.27
:MMEMory:DATA:LENGth?	<filename>[,tag]	6.29
:MMEMory:DCATalog|DDIRectory:LENGth?		6.29
:MMEMory:DATA?	<filename>[, <tag>]	6.28
:MMEMory:DCATalog|DDIRectory?		6.29
:MMEMory:DELete	<filename>	6.30
:MMEMory:LOAD	RAM,<filename>	6.30
:MMEMory:MDIRectory|MD	<directory>	6.31
:MMEMory:MSIS	<drive>	6.31
:MMEMory:RDIRectory|RD	<directory>	6.32
:MMEMory:SCATalog:LENGth?		6.32
:MMEMory:SCATalog?		6.32
:OUTPut: DIGital	ON|OFF	6.33
:OUTPut:CLOCk	ON|OFF	6.33
:OUTPut:FILTer	OFF|2.5MHz|25MHz|EXTernal	6.34
:OUTPut:I:AMPLitude:BALanced	0V to 4V	6.37
:OUTPut:I:AMPLitude[:UNBalanced]	0V to 1V	6.34
:OUTPut:I:BIAS	-2.5 to 2.5 V	6.37
:OUTPut:I:FILTer	OFF|2.5MHz|25MHz|EXTernal	6.34
:OUTPut:I[:STATe]	OFF|FIXed|VARiable|INVerted	6.34
:OUTPut:MARKer<n>:DELay	<samples>	6.36
:OUTPut:MARKer<n>[:STATe]	ON|OFF	6.35
:OUTPut:OIMPedance	R50 | HIGH	6.36
:OUTPut:Q:AMPLitude:BALanced	0V to 4V	6.37
:OUTPut:Q:AMPLitude[:UNBalanced]	0V to 1V	6.35
:OUTPut:Q:BIAS	-2.5 to 2.5 V	6.38
:OUTPut:Q:FILTer	OFF|2.5MHz|25MHz|EXTernal	6.35
:OUTPut:Q[:STATe]	OFF|FIXed|VARiable|INVerted	6.35
:OUTPut:RESolution	8 to 16	6.38
:OUTPut:TYPE	UNBalanced | BALanced	6.36
:PROGram:COPY	<name>	6.39
:PROGram:DELete	<name>	6.39
:PROGram:RUN|EXECute	<name>	6.39
[:SOURce]:CLOCk	<frequency>[,mode]	6.41
[:SOURce]:CORRection:GAIN:I:FIXed	<value>	6.42
[:SOURce]:CORRection:GAIN:Q:FIXed	<value>	6.42
[:SOURce]:CORRection:OFFSet:I:FIXed	<value>	6.42
[:SOURce]:CORRection:OFFSet:I:VARiable	<value>	6.42
[:SOURce]:CORRection:OFFSet:Q:FIXed	<value>	6.43
[:SOURce]:CORRection:OFFSet:Q:VARiable	<value>	6.43
[:SOURce]:CORRection:SKEW	<value>	6.43

[:SOURce]:ROSCillator:SOURce	INTernal|EXTernal	6.43
[:SOURce]:SCLock	EXTSlow | EXTFast | INTernal	6.41
:STATus:OPERation:CONDition?		6.44
:STATus:OPERation:ENABle	0 to 32767	6.44
:STATus:OPERation[:EVENt]?		6.44
:STATus:OPERation:NTRansition	0 to 32767	6.45
:STATus:OPERation:PTRansition	0 to 32767	6.45
:STATus:PRESet		6.46
:STATus:QUEStionable:CONDition?		6.45
:STATus:QUEStionable:ENABle	0 to 32767	6.45
:STATus:QUEStionable[:EVENt]?		6.45
:STATus:QUEStionable:NTRansition	0 to 32767	6.46
:STATus:QUEStionable:PTRansition	0 to 32767	6.45
:SYSTem:BEEPer		6.47
:SYSTem:BEEPer:STATe	ON|OFF	6.47
:SYSTem:COMMunicate:GPIB:ADDRess	0 to 30	6.47
:SYSTem:COMMunicate:SERial:BAUD	1200|2400|4800|9600|19200|38400|57600|115200	6.48
:SYSTem:ERRor?		6.48
:SYSTem:LANGuage	FAST|SLOW	6.48
:SYSTem:OPTion	<name>,<key>	6.49
:SYSTem:PRESet		6.49
:SYSTem:STATe:CATalog:LENGth?		6.49
:SYSTem:STATe:CATalog?		6.49
:SYSTem:STATe:COPY	<source>	6.50
:SYSTem:STATe:DELete	<name>	6.50
:SYSTem:VERSion?		6.50
:TRIGger[:IMMediate]		6.51
:TRIGger:MODE	OFF|GATed|SINGle|CONTinuous	6.52
:TRIGger:SLOPe	POSitive|HIGH|RISing|NEGative|LOW|FALLing	6.52
:TRIGger:SOURce	MANual|BUS|EXTernal	6.53

Tags for Determining the Waveform File Formats

Tags have the general format: **{Name: Data}** or **{Name-length: Data}**

Name / Name-length	Data	Page
CLOCK:	frequency[,SLOW|FAST]	6.55
COMMENT:	string	6.55
COPYRIGHT:	string	6.55
DATE:	yyyy-mm-dd;hh:mm:ss	6.55
FILTER:	value	6.56
IDLE SIGNAL	I, Q	6.57
MARKER LIST x	start-end:value;...	6.56
MARKER LIST x	start value;...	6.56
RESOLUTION:	x y	6.58
TARGET:	name	6.55
TYPE:	magic,xxxxxxxx	6.54
WAVEFORM-length:	start,#xxxxxxxxxxxx...	6.56

7 Examples

Program examples for Remote Control

The following examples explain how to program the instrument and can serve as a basis to solve more complex programming tasks. In the examples, remote control via IEC/IEEE bus and the programming language QuickBASIC are used.

Remote-control commands should be used without the QuickBASIC function names for the serial interface (same as IECIN(), IECOUT() etc). A terminal emulation program may be employed for transmission. If this program has a so-called chat mode (often switched on with the key combination Ctrl-C), commands can be directly entered in a window. The responses are automatically displayed in another window. Without a terminal program, commands can be sent with

```
echo kommando > COM1
```

from the DOS command line. Depending on the interface used, COM1 has to be replaced by COM2. Answers from the instrument cannot always be read in. Furthermore, all characters interpreted by DOS as special characters, cannot be transmitted in this way.

Another possibility to be used on the serial interface is to write the desired commands in a file and to send this file to the instrument with

```
copy -b datei.ext COM1
```

Depending on the interface used, COM1 should be replaced by COM2. In this case answers cannot be read in either but all characters can be transmitted.

Including IEC/IEEE-Bus Library for QuickBasic

```
REM -------------------------- General Declarations ----------------------

COMMON SHARED amiq%
DECLARE SUB IECOUT (out$)
DECLARE SUB IECIN (read$)

REM -------------------------- Include IEC/IEEE-bus library for QuickBasic
'$INCLUDE: 'c:\testtool\qbasic\qbdecl.bas'
REM************************************************************************
```

Initialization and Default Status

The IEC/IEEE bus as well as the settings of the instrument are brought into a defined default state at the beginning of each program. Subroutines "InitController" and "InitDevice" are used to this effect.

Initializing the Controller

```
REM ------------------------- Initialize Controller ----------------------

REM InitController
iecaddress% = 6                         'IEC-bus address of device,
CALL IBFIND("DEV1", amiq%)              'Open port to the instrument.
CALL IBONL(amiq%, 1)
CALL IBPAD(amiq%, iecaddress%)          'Inform controller about instrument
                                        'address,
CALL IBCLR(amiq%)                       'Reset IEC/IEEE-bus operation of the
                                         instrument,
CALL IBEOS(amiq%, 0)                    'Reception terminated with EOI,
CALL IBEOT(amiq%, 1)                    'EOI is set with last character
                                        'to be sent,
CALL IBTMO(amiq%, T10s)                 'Set response time to 10 s.

REM************************************************************************
```

Functions for Receiving and Sending Data and Commands

```
REM ------------------ Functions for receiving and sending ---------------
REM ------------------ data and commands ---------------------------------

REM ------------------ Read data from IEC/IEEE bus -----------------------

SUB IECIN (read$)
  temp$ = SPACE$(100)                   'Delete domain,
  CALL IBRD(amiq%, temp$)               'Read data from IEC bus.
  read$ = LEFT$(temp$, IBCNT%)          'and discard the rest.
  END SUB

REM ------------------ Output on IEC/IEEE bus ----------------------------
---

SUB IECOUT (out$)
  wrt$ = out$ + CHR$(&HD) + CHR$(&HA)
  CALL IBWRT(amiq%, wrt$)
REM************************************************************************
END SUB

REM************************************************************************
```

Initializing the Instrument

The IEC/IEEE-bus status registers and instrument settings of the AMIQ are brought into the default state.

```
REM ------------------ Initialize the instrument -------------------------

REM InitDevice
CALL IECOUT("*CLS")                     'Reset status registers,
CALL IECOUT("*RST;*WAI")                'Reset the instrument.

REM************************************************************************
```

Sending Device Setting Commands

In this example a waveform file is copied from the floppy to the AMIQ hard disk (so that it will be available later on) and then loaded into the output buffer. Subsequently the marker output 1 is programmed so that it is at high level for the first 100 samples and then low level (the end is specified as a very large number, larger than the waveform). Thus a start marker is obtained. The output sockets are switched to a constant level. The trigger system is set to continuous output and then the waveform output is started.

Since QuickBASIC would interprete double inverted commas in a command line as end of the command, simple quotation marks are used instead. AMIQ handles them like double inverted commas.

Generally, no name extension is specified for file names. AMIQ uses fixed name extensions for the various file types. For waveform files the extension is .wv.

```
REM ----------------- Device setting commands ----------------------------
CALL IECOUT("MMEM:COPY 'a:\gsm', 'gsm'")     'Copy file "gsm.wv"
CALL IECOUT("MMEM:LOAD RAM, 'gsm'")          'Load file into the output
                                             buffer

CALL IECOUT("MARK1 '0-100:1;101-999999:0'") 'Marker output 1 high for the
                                             'first 100 samples
CALL IECOUT("OUTP:I FIX; Q FIX")             'Sets both outputs to a fixed
                                             'max. level of 1 V
CALL IECOUT("TRIG:MODE CONT")                'Continuous signal generation
CALL IECOUT("ARM;:TRIG")                     'Starts signal generation

REM*************************************************************************
```

Switchover to Manual Control

This may be necessary when several remote-control sources should be used successively.

```
REM ------------------ Switch instrument to manual control ---------------
CALL IBLOC(amiq%)                        'Sets instruments to local state.
REM*************************************************************************
```

The following alternative is possible but not recommended. It should only be used for the serial interface.

```
REM ------------------ Switch instrument to manual control ---------------
CALL IECOUT("*GTL")                      'Sets instruments to local state.
REM*************************************************************************
```

Executing Batch Programs

AMIQ is able to execute a list of IEC/IEEE-bus commands from a file. In this file all IEC/IEEE-bus commands can be used. All outputs are written into a file of the same name in the same directory as the batch file, but with the extension .log.

```
REM ------------------ Readout of device settings ---------------------
CALL IECOUT("PROG:RUN 'sequence'")     'Starts batch file "sequence.iec"
                                       'from the floppy; if it is not found
                                       on the floppy from the hard disk.
```

Reading out Device Settings

A number of device settings are read out here. The short form of the commands is used.

```
REM ------------------- Read out device settings -------------------------
CALL IECOUT("MMEM:LOAD?")              'Requests name of currently
                                       'loaded waveform file,
CALL IECIN(WaveformName$)              'Input value.

CALL IECOUT("MMEM:DATA? ' + Waveformname$ + ', 'copyright'")
                                       'Requests copywrite comment of the
                                       'loaded waveform file.
CALL IECIN(Copyright$)                 'Input value.

CALL IECOUT("OUTP:MARK1:DEL?")         'Requests delay of marker 1 output
                                       '(in samples),
CALL IECIN(Delay$)                     'Input value.


REM ------------------- Display of values on screen ------------------------
PRINT "Waveform file loaded:"; Waveformname$
PRINT "Copyright by "; Copyright$
PRINT "Marker 1 Delay:"; Delay$

REM************************************************************************
```

Command Synchronization

Execution of commands in the AMIQ is consecutive, never overlapping. For this reason an explicit synchronization of commands is not required. However, it is often desirable to inform the host computer about the end of a longer action (eg copying a file from a floppy).

```
REM ------------ Examples for synchronization with the host: -----------

REM ------------Because repeated access has to be made to the hard disk
REM ------------command MMEM:COPY has a relatively long execution time.-
REM ------------It has to be ensured that the host continues the--------
REM ------------program only after the waveform file has been completely
REM-------------copied. ---------------------------------------

CALL IECOUT("MMEM:COPY 'a:\gsm', ':'") Copies "gsm.wv" file

REM ------------First option: Use *OPC? ----------------------------

CALL IECOUT("*OPC?")

REM ------------Here the controller can drive other devices-------------

CALL IECIN(OpcOk$)                      'Waiting for the 1 of *OPC?'
                                        'the waveform is completely copied

REM ------------Second option: Use *OPC request ----------------------------
REM ------------In order to use the *OPC request function with the---
REM-------------National Instruments GPIB driver, the "Disable Auto ----
REM-------------Serial Poll" setting must be changed to "yes" by -------
REM-------------means of IBCONF'

CALL IECOUT("*SRE 32")                  'Enable service request for ESR,
CALL IECOUT("*ESE 1")                   'set event enable bit for
                                        'operation complete bit.

ON PEN GOSUB OpcReady                   'Initialize service
                                        'request routine.
PEN ON
CALL IECOUT("*OPC")

REM ------------Continue main program ----------------------------

STOP                                    'end of program.

OpcReady:
REM ------------This subroutine is executed when ------------------
REM ------------copying is complete ----------------------------
REM ------------Program reaction to the OPC service ----------
REM ------------request, eg

PRINT "Please remove disk from floppy disk drive"
RETURN

REM*************************************************************************
```

Service Request

The service request routine requires an extended initialization of the instrument in the course of which the respective bits of the transition and enable registers are set.

In order to use the service request function in conjunction with a National Instruments GPIB driver, the "Disable Auto Serial Poll" setting must be changed to "yes" by means of IBCONF.

```
REM --------- Example of initialization of the SRQ in the case of errors --
CALL IECOUT("*CLS")                          'Resets status reporting system.
CALL IECOUT("*SRE 168")                      'Enables service request for the
                                             'STAT:OPER,STAT:QUES and ESR
                                             'registers,
CALL IECOUT("*ESE 61")                       'Sets event enable bit for
                                             'command execution, device-
                                             'dependent and query errors,
CALL IECOUT("STAT:OPER:ENAB 32767")          'Sets OPERation enable bit
                                             'for all events,
CALL IECOUT("STAT:OPER:PTR 32767")           'Sets associated OPERation
                                             'PTRansition bits,
CALL IECOUT("STAT:QUES:ENAB 32767")          'Sets questionable enable bits
                                             'for all events,
CALL IECOUT("STAT:QUES:PTR 32767")           'Sets associated questionable
                                             'PTRansition bits,
ON PEN GOSUB Srq                             'Initializes service
                                             'request routine.
PEN ON
REM ------------------- Main program continued here -----------------------
STOP                                         'End of program
REM************************************************************************

Srq:
REM ------------------- Service Request Routine --------------------------
DO
   SRQFOUND% = 0
   FOR I% = UserN% TO UserM%                 'Polls all bus users.
          ON ERROR GOTO noUser               'No user existing.
          CALL IBRSP(I%, STB%)               'Serial poll, read status byte.
          IF STB% > 0 THEN                   'This instrument has bits set
                                             'in the STB.
               SRQFOUND% = 1
               IF (STB% AND 16) > 0 THEN GOSUB Outputqueue
               IF (STB% AND 4) > 0 THEN GOSUB Failure
               IF (STB% AND 8) > 0 THEN GOSUB Questionablestatus
               IF (STB% AND 128) > 0 THEN GOSUB Operationstatus
               IF (STB% AND 32) > 0 THEN GOSUB Esrread
          END IF

noUser:
   NEXT I%
LOOP UNTIL SRQFOUND% = 0
ON ERROR GOTO Errorhandling
ON PEN GOSUB Srq: RETURN                     'Re-enables SRQ routine;
                                             'End of SRQ routine.

REM************************************************************************
```

```
REM ------------ ------ Subroutines for the individual STB bits ---------
Outputqueue:                              ' Reads output queue.
CALL IECIN(Nachricht$)
PRINT "Message in output queue:"; Message$
RETURN

Failure:                                  'Reads error queue.
CALL IECOUT("SYSTEM:ERROR?")
CALL IECIN(ERROR$)
PRINT "Fehlertext :"; ERROR$
RETURN


Questionablestatus:                       'Reads questionable status register.

CALL IECOUT("STATus:QUEStionable:EVENt?")
CALL IECIN(Ques$)
RETURN

Operationstatus:                          'Reads operation status register.
CALL IECOUT("STATus:OPERation:EVENt?")
CALL IECIN(Oper$)
IF (VAL(Oper$) AND 2) > 0 THEN PRINT "Adjustment running"
IF (VAL(Oper$) AND 2) > 0 THEN PRINT "Hardware settling"
IF (VAL(Oper$) AND 32) > 0 THEN PRINT "Waiting for trigger"
RETURN


Esrread:                                  'Reads event status register,
CALL IECOUT("*ESR?")                      'reads ESR.
CALL IECIN(Esr$)
IF (VAL(Esr$) AND 1) > 0 THEN PRINT "Action terminated"
IF (VAL(Esr$) AND 4) > 0 THEN GOTO Failure
IF (VAL(Esr$) AND 8) > 0 THEN PRINT "Internal error"
IF (VAL(Esr$) AND 16) > 0 THEN GOTO Failure
IF (VAL(Esr$) AND 32) > 0 THEN GOTO Failure
IF (VAL(Esr$) AND 128) > 0 THEN PRINT "'Power on"
RETURN
REM ********************************************************

REM ------------------ Error routine ----------------------------------
Errorhandling:
PRINT "ERROR"                             'Output error message,
STOP                                      'Aborts program.
REM*************************************************************************
REM*************************************************************************
```

Selftest with Progress Indication

In the following example a selftest with progress indication is implemented. The programming language used is C combined with the IEC/IEEE-bus driver GPIB.COM by National Instruments.

```
#include <stdio.h>
#include <string.h>
#include <stdlib.h>
#include <conio.h>
#include <bios.h>
#include "C:\NI-GPIB\C\DECL.H"

void report_error(int fd, char *errmsg)
{
```

```
   fprintf(stderr, "Error %d: %s\n", iberr, errmsg);
   if (fd != -1) {
      printf("Cleanup: taking board off-line\n");
      ibonl(fd,0);
   }
exit(1); // Abort program
}

void cmnd_out (int amiq, char *befstr)
{
   ibwrt(amiq, befstr,(long)strlen(befstr));
   if (ibsta & ERR)
      report_error (amiq, "Could not initialize AMIQ");
}

void query_in (int amiq, char* reading)
{
 ibeos (amiq,0x140A);
 ibrd(amiq, reading, 100);
  if (ibsta & ERR)
   report_error (amiq, "Could not read data from AMIQ");
  reading[ibcnt-1] = '\0'; // overwrite LF with string terminator
}

void check_errorqueue (int amiq)
{
 char reading[101];
 while (1)
  {
   cmnd_out (amiq,"SYST:ERR?");     read error queue
   query_in (amiq,reading);
   if (reading[0] == '0')  // wait for "0,No Error"
    return;
   printf ("%s\n",reading);
  }
}

void main()
{
   int    amiq;        /* File handle for AMIQ */
   int    i;
   char   iec_befehl [80];
   char   reading [101];
   char *st_comp[] =
    {
     "BASics?      ",
     "DSYStem?     ",
     "DACReference?",
     "OADJust?     ",
     "OFFSet?      ",
     "REFFrequency?",
     "VCO?         ",
     "LEVels?      ",
     "ATTenuators? ",
     "LPASs?       "
    };

   if ((amiq = ibdev(0, 6, 0, T1, 1, 0)) < 0)
       report_error (amiq, "Could not initialize AMIQ");

   /* Selftest with progress indication */
   cmnd_out (amiq,"*SAV 'TEMP'"),     save current setup
   for (i = 0; i < 10; i++)
```

```
    {
     sprintf (iec_befehl,"DIAG:SELF:%s",st_comp[i]); // Selftest command
     printf ("%s ",st_comp[i]);                      // put together
     cmnd_out (amiq,iec_befehl);
     query_in (amiq,reading); // Response to query '0' (o.k.) or '1' (Error)
     if (reading[0] == '0')
      printf ("passed!\n"); // no error
     else
      check_errorqueue (amiq); // read out error queue
    }
   cmnd_out (amiq,"*RCL 'TEMP'"); // fetch setup before selftest
   ibonl(amiq, 0); /* Take amiq off-line */
}
```

Waveform Descriptions

CDMA waveform descriptions

Waveform directory/name	Description	Comments
CDMA/pilot	CDMA pilot signal, with baseband filter cdma-bs.ifl Peak/ave ratio is 6.9 dB	Cdma_bs.ifl is similar to the filter used in SMIQ/E option B42, providing the best ACPR and EVM
CDMA/pilotL	CDMA pilot signal with baseband filter cdma705.ifl Peak/ave ratio 6.9 dB	This filter has been optimized for ACPR measurement margin at 705 kHz, a common requirement with many BTS amplifier manufacturers.
CDMA/9CH_SMIQ	BTS signal, pilot, sync and paging plus 6 randomly assigned traffic channels per IS-97 recommendation. Peak/ave ratio 11.45 dB Walsh codes 0,1,9,10,11,15,17,25,32	Uses same channel assignments as SMIQ/E option B42
CDMA/9CHSMIQL	BTS signal, pilot, sync and paging plus 6 randomly assigned traffic channels per IS-97 recommendation. Uses baseband filter cdma705.ifl. Peak/ave ratio 11.45 dB Walsh codes 0,1,9,10,11,15,17,25,32	Low ACPR filter used to improve measurement margin
CDMA/9CHBad	BTS signal with Walsh codes 0,4,8,16, 24, 32, 40, 48 and 56. This yields worst case peak to average ratio for a nine channel signal. Peak/ave ratio 15 dB.	Used to produce worst case ACPR results in components. Similar to SMIQ/E option B42 09Bad selection
CDMA/9CHBadL	BTS signal with Walsh codes 0,4,8,16, 24, 32, 40, 48 and 56. This yields worst case peak to average ratio for a nine channel signal. Uses baseband filter cdma705.ifl. Peak/ave ratio 15 dB.	Used to produce worst case ACPR results in components. Similar to SMIQ/E option B42 9Bad selection, plus low ACPR filter used to improve measurement margin.
CDMA/64CHSMIQ	BTS signal with all 64 Walsh codes active. Pilot at –7 dB, all other Walsh codes set to –19 dB below carrier. Peak/average ratio 17.3 dB	This is the same as the default 64-channel signal provided in the SMIQ/E option B42. This is not a realistic base station signal, as it is never the case that all 64 Walsh codes are active, but it does provide a high peak/average ratio for stress testing components.
CDMA/3C-64CHL	Three carriers, spaced at 1.25 MHz, using 64 Walsh coded channels on each carrier	Uses low ACPR filter, can be used for worst case three carrier testing.
CDMA/3PilotsL	Three pilot-only carriers, spaced at 1.25 MHz, Walsh Code 0 active	Uses low ACPR filter. Represents lowest peak/ave ratio in a multi-carrier CDMA signal.
CDMA/3C-9CHL	Three carriers, spaced 1.25 MHz, with Walsh code assignment as follows Lower Carrier: 0,1,9,10,11,15,17,25, 32 Middle carrier: 0,2, 11,13,19,22, 32, 36, 55 Upper carrier: 0,3, 14,18,23,32,45,49,61 All power levels per IS-97 recommendation	A typical three carrier signal, with uncorrellated Walsh codes Uses cdma705.ifl filter for low ACPR

Waveform directory/name	Description	Comments
CDMA/3C-9CH	Three carriers, spaced 1.25 MHz, with Walsh code assignment as follows Lower Carrier: 0,1,9,10,11,15,17,25, 32 Middle carrier: 0,2, 11,13,19,22, 32, 36, 55 Upper carrier: 0,3, 14,18,23,32,45,49,61 All power levels per IS-97 recommendation	A typical three carrier signal, with uncorrellated Walsh codes Uses cdma_bs.ifl filter
CDMA/3C9CHBL	Three carrier, spaced 1.25 MHz with identical Walsh codes on all carriers 0.4,8,16,24,32,40,48,56 All power levels per IS-97 recommendation	Worst case signal for nine Walsh coded channels. Uses cdma705.ifl filter for low ACPR
CDMA/3C9CHBAD	Three carrier, spaced 1.25 MHz with identical Walsh codes on all carriers 0.4,8,16,24,32,40,48,56 All power levels per IS-97 recommendation	Worst case signal for nine Walsh coded channels. Uses cdma_bs.ifl filter for low EVM
CDMA/ 3C2p5	3 carriers, random Walsh on each carrier, 2.5 MHz spacing	Provides open channels between each carrier for ACPR testing. Uses cdma_bs.ifl filter
CDMA/reverse	Reverse link signal	For mobile component testing

Waveform descriptions, W-CDMA and W-CDMA multi-carrier

Waveform Directory/Name	Description	Comments
WCDMA/1DPCH	Single Dedicated Physical Channel	ACPR –60 dBc, -64 dBc with option SMIQ-B46
WCDMA/1D1P	Single DPCH+Perch	Represents simplest base station signal
WCDMA/12D1P	12 DPCH + Perch, Data Offset 3, Long code offset 5 Peak/ave ratio 11.14	Represents lightly loaded W-CDMA base station with typical peak/ave ratio
WCDMA/12D1Pbad	12 DPCH = Perch, no data or long code offsets peak/ave ratio 14.3	Worst case peak/average for 12 traffic channels
WCDMA/127D1P	127 DPCH+Perch, data offset 3, long code offset 5 peak/ave ratio 10.64	Fully loaded base station. ACPR-58 dBc, -62 dBc with SMIQ-B46
WCDMA/8Mchip	1 DPCH, 8.192 Msymbols/sec	
WCDMA/16Mchip	1DPCH, 16.384 Msymbols/sec	
WCDMA/2C1D5M	2 carriers, 1DPCH + Perch, 5 MHz spacing	
WCDMA/2C1D15M	2 carriers, 1 DPCH + Perch, 15 MHz spacing	

Waveform descriptions, NADC, GSM, CW multi-carrier and MISC

Waveform Directory/Name	Description	Comments
NADC/downlink	Continuous NADC modulation, PRBS9 data	No time slots, useful for component testing
NADC/nadcsyn2	Single time slot NADC signal	Uses sync word 2
NADC/2_1p5M	Two NADC carriers, 1.5 MHz spacing, different start values for PRBS9 data sequence	Different start values are required in PRBS to simulate peak/ave ratio of channels with different data. Use of the same PRBS on each carrier would result in very high peak/ave. IQ impairments in the SMIQE can be used to minimize residual carriers (in SMIQ/E menu: Vector Mod/Impairments/On , use IQ offset and imbalance) –65 dBc intermodulation performance typical
NADC/5C_3p75M	5 NADC carriers, 3.75 MHz spacing, different start values for PRBS9 data sequence on each carrier	Intermodulation optimization is not required on odd number carriers. –63 dBc typical intermodulation performance
NADC/10_120K	10 NADC carriers, 120 kHz spacing, different start values for PRBS9 data sequence on each carrier	Same performance and optimization procedure as other even numbered carrier waveforms
NADC/10_1p5M	10 NADC carriers, 1.5 MHz spacing, different start values for PRBS9 data sequence on each carrier	Same performance and optimization procedure as other even numbered carrier waveforms
GSM/5_813K	5 GSM carriers, PRBS9, 813 kHz spacing	
GSM/noslots	GSM signal, PRBS9, no power ramping	Useful for component test
GSM/gsm_slo1	GSM single time slot	Sync word 1
CW/2_1M	2 CW tones, 1 MHz spacing	Same performance and optimization procedure as other even numbered carrier waveforms
CW/3_1M	3 CW tones, 1 MHz spacing	
CW/9_100K	9 CW tones, 100 kHz spacing	
CW/15_1M	15 CW tones, 1 MHz spacing	
MISC/RECEIVER	Receiver test demo waveform	QPSK signal with noise and CW interferer

APPL_MAN waveform descriptions *

Waveform directory/name	Description	Comments
APPL_MAN/CW8C	8 CW carriers with 240 kHz spacing	all start phases equal, maximum crest factor
APPL_MAN/CW8C_OP	8 CW carriers with 240 kHz spacing	optimized start phases for minimum crest factor
APPL_MAN/NA10C120	10 NADC carriers with 120 kHz spacing	Data on different channels uncorrelated
APPL_MAN/NA2C12M	2 NADC carriers with 12.15 MHz spacing	Data on different channels uncorrelated
APPL_MAN/GSM_2CAR.	2 GSM carriers with varying power, 400 kHz spacing	Timeslot 1 active on first carrier, timeslot 5 active on second carrier
APPL_MAN/WCD_2CAR	2 W-CDMA carriers with 10 MHz spacing, 15 DTCH per carrier	No longcode or data offset on first (left) carrier, data offset on second (right) carrier
APPL_MAN/BER_SELF**	For BERT stand-alone demonstration	User-data error-free
APPL_MAN/BER_SERR**	For BERT stand-alone demonstration	User data contains 2 errors
APPL_MAN/BER_TEST**	For BERT demonstration with FSE as device under test	User-data error-free
APPL_MAN/BER_ERR**	For BERT demonstration with FSE as device under test	User data contains 2 errors
APPL_MAN/BER_DEL**	For BERT demonstration with FSE as device under test	For setup calibration (compensating signal path delay)
APPL_MAN/ COS_SIN	Sinewave signal with 1 MHz frequency	cosine on I output, sine on Q output
APPL_MAN/NOISE	Noise (AWGN) signal with 30 MHz bandwidth	
APPL_MAN/NSE_FILT	Filtered noise (AWGN) signal	Signal shaped with CDMA BTS filter, noise signal approximates real multi-channel CDMA signal

* Setups and creation are described in WinIQSIM Application Manual
** See Application Note 1GP36_0E for usage.

8 Maintenance

The following chapter contains information on the maintenance of AMIQ.

Please follow the instructions in the service manual when exchanging modules or ordering spares. The Order Nos. for spare parts can be found in the service manual.

The address of our support center and a list of all Rohde & Schwarz service centers can be found at the beginning of this manual.

The service manual includes further information particularly on troubleshooting, repair, exchange of modules and calibration.

Mechanical and Electrical Maintenance

AMIQ does not require any special maintenance. Remove any contamination on the instrument by means of a soft cloth. Make sure that the air vents are not obstructed.

Storing and Packing

AMIQ can be stored at a temperature of –40°C to +70°C. When stored for an extended period of time the instrument should be protected against dust.

The original packing should be used, particularly the protective covers at the front and rear, when the instrument is to be transported or dispatched. If the original packing is no longer available, use a sturdy cardboard box of suitable size and carefully wrap the instrument to protect it against mechanical damage.

9 Error Messages

This chapter permits simple faults to be localized and contains a list of all error messages generated by AMIQ. Detailed information on troubleshooting and repair is given in the service manual.

Troubleshooting

When an error occurs in the AMIQ, two cases have to be distinguished:

1. The instrument starts "normally" but detects an error. This is signalled by a fast flash of the ON LED.

   In this case the device software functions properly and the error can be read out via IEC/IEEE bus or RS-232 interface. The error message can be queried with `:SYS:ERR?` (see "List of error messages" in this chapter).

   The error message provides further information on the error and where the error occurred. With the aid of special service commands (see service manual) the hardware can be set and checked.

   If ON LED flash fast but `SYS:ERR?` doesn't indicate an error, it is only a hint that AMIQ doesn't generate any curve at the moment. It appears whenever a curve was stored directly to the AMIQ's SDRAM to save time before switching off AMIQ by means of the `MEM:DATA RAM, <binary block data>` command (e.g. via WinIQSIM and the settings **Transmission**, **Force internal**, **Destination AMIQ-RAM).** This can be avoided by loading curves via a waveform file and the command `MMEM:LOAD RAM, 'filename.WV'`. Such a curve will be available immediately after power-up of AMIQ.

2. The instrument does not start. This may have several reasons:

Table 9-1 Error symptoms

Symptoms shown by AMIQ	**Possible reasons** ➢ **Error elimination**
The ON LED does not light immediately after power up.	➢ Check fuses in the power connector (see "Power Fuses" in chapter 1).
The ON-LED lights, then the CONTROL LED lights briefly. The ON-LED alone continues lighting steadily but the instrument does not accept any commands.	A setting may lead to a long start-up time. Since AMIQ is started with the status set before switching off, also the previous waveform is loaded. If this is a curve with a great number of points (up to 16 million points for AMIQ04), loading may take up to more than 2 minutes.
The three LEDs do not light briefly. The built-in PC does not start.	A fault has occurred in the setting of the internal PC. This fault may be caused by a flat lithium battery. ➢ Replace battery and reset the BIOS of the PC (see service manual).

Note: *Loading may take up to a minute if the setting contains a very lagre output curve. Thus the timeout of the controller may be reached before a curve is completely loaded. This is why it is recommendable to set the timeout to a relatively large value for AMIQ operation.*

List of Error Messages

AMIQ is able to generate information, warning and error messages. If an event occurs which has to be signalled, the AMIQ software enters the respective message in an error queue. Up to 10 messages can be entered in the queue. These error messages can be read successively by a repeated use of the `:SYST:ERR?` command. If there are no more messages in the queue, 0 (no error) is returned.

Note: *Even if the condition causing an entry in the queue disappears again, the entry remains in the queue unit it is read by means of :SYST:ERR?.*

Reading the error queue clears the entries.

SCPI Standard Messages

SCPI error messages are the same in all SCPI instruments. The errors are assigned negative numbers. The standard text of the error message is often supplemented by a comment from AMIQ which provides more detailed information (device-dependent information), eg -250, "Mass storage error; directory in use". Since this part depends on the individual situation, it often contains more relevant information than the standard text.

No error

Error code	Explanation
0	**No error** This message is output when there are no entries in the error queue.

Operation complete

Error code	Explanation
-800	**Operation Complete** This message is entered in the error queue after an *OPC on the conclusion of all operations.

Query error - error upon data request

When the following error codes are output, bit 2 is set in the ESR register.

Error code	Explanation
-420	**Query UNTERMINATED** An incomplete query was received. Example: the device is addressed to talk although the received query was incomplete.
-410	**Query INTERRUPTED** The query was interrupted. Example: a query is followed by new data before a response was completely sent.

Device-specific error

The following errors cause bit 3 in the ESR register to be set.

Error code	Explanation
-360	**Communication error** An error was detected at the lowest data transmission level. Example: the status transition of an IEC/IEEE-bus handshake line was not correct.
-350	**Queue overflow** Error code entered in the queue in lieu of the code when the queue is full. It indicates that an error occurred but was not recorded in the queue. The original error message is lost.
-340	**Calibration failed** The internal calibration was not successful.
-330	**Self-test failed** An error occurred during the internal selftest.
-315	**Configuration memory lost** Nonvolatile configuration data saved by the device have been lost.
-313	**Calibration memory lost** Nonvolatile calibration data used by the CAL system have been lost.
-310	**System error** An unspecified system error has occurred.

Execution error

The following errors cause bit 4 in the ESR register to be set.

Error code	Explanation
-257	**File name error** The specified file name cannot be used, eg because the file does not exist (reading, clearing) or already exists (writing, generation)
-256	**File name not found** A file with the specified name does not exist.
-255	**Directory full** The specified directory is full - no more files can be written.
-250	**Mass storage error** A mass storage error occurred, eg an attempt was made to change to a non-existing directory or to clear the current directory.
-240	**Hardware failed** A hardware component (eg the EEPROM in which calibration data are stored) could not be accessed.
-232	**Invalid format** Format or structure of a waveform file is inappropriate, eg a necessary tag is missing.
-225	**Out of memory** The AMIQ software has insufficient memory to perform the requested operation.
-223	**Too much data** More data were sent by the host than the AMIQ can handle.
-222	**Data out of range** A value of the transmitted command was outside the legal range.
-221	**Settings conflict** A setting contradicts another setting. The last attempted setting was not executed.

Command error

The following errors cause bit 5 in the ESR register to be set.

Error code	Explanation
-168	**Block data not allowed** The command contains legal block data which are not allowed at this point.
-161	**Invalid block data** The command contains illegal block data, eg no numeric data element is sent after the introductory #.
-158	**String data not allowed** The command contains a legal string data element which is not allowed at this point.
-148	**Character data not allowed** The character data is prohibited for this command or at this point of the command.
-144	**Character data too long** The character data element contains more than 12 characters.
-141	**Invalid character data** The character data element contains an invalid character or the element is not valid for this command.
-138	**Suffix not allowed** A suffix is not allowed for this command or at this point of the command.
-134	**Suffix too long** The suffix contains more than 12 characters.
-131	**Invalid suffix** The suffix is not appropriate for this command.
-128	**Numeric data not allowed** The command contains a numeric data element the device does not accept in this position.
-124	**Too many digits** The decimal numeric data element contains too many digits.
-123	**Exponent too large** The magnitude of the exponent is too large.
-114	**Header suffix out of range** The command contains an illegal numeric suffix.
-113	**Undefined header** The sent command header has not been defined.
-112	**Program mnemonic too long** The header contains more than 12 characters.
-109	**Missing parameter**

Error code	Explanation
	The command does not contain the required parameters.
-108	**Parameter not allowed** The command contains parameters at a position where they are not accepted.
-105	**GET not allowed** A GET was received within a program message.
-104	**Data type error** The recognized data element is of the wrong type (eg character data instead of numeric data)
-103	**Invalid separator** The semicolon was omitted after a program message unit.
-102	**Syntax error** The data type received is not accepted at this position.
-101	**Invalid character** The command contains a character which is invalid for that type.
-100	**Command error** Generic error message that cannot detect a more specific error.

AMIQ-Specific Messages

AMIQ-specific messages are used for errors for which SCPI does not provide a specific error message. The numbers of AMIQ-specific messages are positive.

Error code	Explanation
251	**Bad file format** The file (waveform, setup, batch, etc) has an illegal format, eg it belongs to a previous program version, is incomplete or damaged.
312	**Old EEPROM version found and upgraded** The nonvolatile EEPROM for storing calibration data and important information was programmed with a previous program version. This message is not an error but an information. The EEPROM is automatically updated. Missing values are appropriately preset.
313	**EEPROM checksum error; using default value** The contents of the EEPROM and the backup are damaged. AMIQ uses appropriate preset values instead of the values stored. It is recommended to call again the internal calibration routines.
314	**EEPROM corrupt; restored from backup** The contents of the EEPROMs is damaged and is replaced by a backup copy stored on the internal hard disk. No data are lost.
315	**Old setup file, using some defaults** A device status activated on power up or by *RCL was generated by a previous program version and does not contain the required values for all settings. The file is automatically updated; appropriate presettings are used for the missing values
330	**Initialisation failed** Initialization of a hardware or software component failed after power-up.
340	**Calibration failed for external filter** This is not an error and for information only. Most of the calibration routines determine calibration values for each filter setting, ie also for external filters. If no external filter is connected, the calibration routine does not converge and is not able to obtain a value. The previous value remains unchanged. To avoid this message being output, external filters (consisting of a cable in the simplest case) should be connected for the two channels between the filter input and output before the calibration routine is called up.

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